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## U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN 193.

A. C. TRUE, Director.

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STUDIES OF THE EFFECT OF  
DIFFERENT METHODS OF COOKING  
UPON THE THOROUGHNESS AND EASE  
OF DIGESTION OF MEAT

AT THE UNIVERSITY  
OF ILLINOIS.

BY

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Mar 31 1903  
B. & L.

## LETTER OF TRANSMITTAL.

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U. S. DEPARTMENT OF AGRICULTURE,  
OFFICE OF EXPERIMENT STATIONS,  
*Washington, D. C., June 20, 1907.*

SIR: I have the honor to transmit herewith and recommend for publication as Bulletin 193 of this Office, a report of investigations on the digestibility and nutritive value of meat, conducted by H. S. Grindley, professor of general chemistry in the college of science of the University of Illinois, Timothy Mojonnier, and Horace C. Porter, as a part of the cooperative nutrition investigations of this Office. The report includes the results of 67 natural and 99 artificial digestion experiments with meat, undertaken to determine the ease and thoroughness of digestion of different kinds and cuts of meats cooked in a variety of ways. These studies form a part of the investigations which have been in progress at the University of Illinois from 1898 to 1907 to determine the effects of cooking upon the nutritive value of meat.

The results reported are of widespread interest, as they show that meat of all sorts is to be classed among the very digestible foods, and that differences in kind, cut, or method of preparation for the table have less effect upon the ease or the thoroughness of digestion than has been frequently claimed.

The editorial work in preparing the reports of these investigations for publication was done by R. D. Milner of this Office.

Respectfully,

A. C. TRUE,  
*Director.*

Hon. JAMES WILSON,

*Secretary of Agriculture.*

## CONTENTS.

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	Page.
Introduction.....	5
Experiments on the thoroughness of digestion of meats.....	5
Work of other investigators.....	6
Investigations here reported.....	6
Experimental methods.....	7
Composition of food materials.....	7
Composition of feces.....	10
Details of experiments with mixed diet, including meat .....	12
Experiments with amounts of food not restricted.....	12
Experiments with definite amounts of food and of uniform muscular exercise.....	15
Experiments with varying amounts of food and of muscular exercise..	19
Details of experiments with simple diet, including meat.....	24
Experiments with lean beef cooked in water for 1 hour .....	27
Experiments with lean beef cooked in water for 2 hours .....	28
Experiments with lean beef cooked in water for 3 hours .....	30
Experiments with lean beef pan broiled.....	31
Experiments with lean beef fried.....	32
Experiments with lean beef roasted.....	32
Experiments with fat beef cooked in water for 2 hours .....	33
Experiments with beef ribs roasted.....	34
Experiments with fat veal leg roasted.....	36
Experiments with mutton leg roasted.....	38
Experiments with pork roasted.....	39
Summary and discussion of results.....	40
Digestibility of the nitrogen (protein) as corrected for metabolic products in the feces.....	47
Income and outgo of nitrogen and gain or loss of protein.....	52
Investigations on the ease or rapidity of digestion of meat.....	59
Examination of stomach contents.....	59
Artificial digestion experiments.....	61
Investigations here reported .....	63
Development of method.....	64
Tests of method adopted.....	72
Details of experiments on the ease of digestion of protein.....	76
Experiments with beef.....	78
Experiments with mutton.....	89
Experiments with pork.....	90
Summary and discussion of results.....	94
Conclusions.....	99

# EFFECT OF COOKING UPON DIGESTION OF MEAT

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## INTRODUCTION.

In connection with the nutrition investigations of the Department of Agriculture studies have been made at the University of Illinois, in cooperation with the Office of Experiment Stations, of the various factors which affect the nutritive value of meats. A part of this inquiry has been discussed in previous bulletins<sup>a</sup> of this Office, which report studies of the changes in the nature and proportions of the nutritive ingredients of the meat that are produced by cooking. Another part of the research is taken up in the present bulletin, which reports investigations on the effect of cooking upon the digestibility of the meat. Two lines of work have been followed in these investigations. The more important concerns the thoroughness with which different kinds and cuts of meats, cooked in different ways, may be digested by man in normal health—that is, the proportions of the nutrients of the meats that would be actually dissolved and absorbed during their passage through the alimentary canal. In addition to this, however, an attempt was made by means of artificial digestion experiments to gain some knowledge regarding the effect of cooking in general, and different methods of cooking in particular, upon the ease or rapidity of the peptic digestion of the proteid of the meat.

## EXPERIMENTS ON THE THOROUGHNESS OF DIGESTION OF MEATS.

The thoroughness with which a given food material may be digested can be studied satisfactorily only by means of natural digestion experiments in which the quantities of nutrients in the material eaten are determined and compared with those in the feces excreted. Such experiments are sometimes made with dogs and other animals, but the most satisfactory are those made with men. Only those made with men are here considered.

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<sup>a</sup> U. S. Dept. Agr., Office of Experiment Stations Buls. 102, 141, 162.

## WORK OF OTHER INVESTIGATORS.

A number of investigators have studied the thoroughness of digestion of cooked meat. For example, Hofmann<sup>a</sup> compared the digestibility of meat protein with that of vegetable foods. Rubner<sup>b</sup> studied the digestibility of roasted lean beef in connection with an extended study of the digestibility of single food materials. Atwater<sup>c</sup> studied the comparative digestibility of beef and fish, in an investigation on the nutritive value of these two kinds of animal food. An experiment was made by Malfatti<sup>d</sup> with roasted and boiled beef. Solntzev<sup>e</sup> made experiments with canned beef and mutton and with similar meats freshly prepared and cooked in water at 85° C.; and Smetski<sup>f</sup> studied the assimilation of the nitrogenous constituents of boiled salt meat. Solomin<sup>g</sup> investigated the digestibility of tripe. No attempt has been made to include here a complete summary of the work of this nature, for the reason that in general the results of experiments such as these do not throw much light on the question as to what effect different methods of cooking have upon the digestibility of the meat. C. Forster,<sup>h</sup> however, has published the results of an extended study of the digestibility of different cuts of beef cooked in different ways as compared with that of raw beef. These are considered in some detail on page 45, in a comparison with the results obtained in the investigations reported in the present bulletin.

### INVESTIGATIONS HERE REPORTED.

In the present bulletin the results of 67 digestion experiments with men are given. These experiments were of two kinds. In 23 of them the meat was eaten in a rather varied ration, the purpose being to determine the effect of different methods of cooking meat upon the digestibility of an ordinary mixed diet, including meat, beef being the meat selected. In the remaining 44 experiments the meat was eaten in a very simple diet, the food materials other than meat being those the digestibility of which is fairly well established, so that by making due allowance for these the digestibility of the meat itself may be calculated. Of these, 31 experiments were with beef cooked in water for different lengths of time, and by roasting, trying,

<sup>a</sup> Reported by Voit in Sitzber. K. Bayer. Akad. Wiss. Math. Phys. Kl., 1869, Pt. 2, p. 483.

<sup>b</sup> Ztschr. Biol., 15 (1879), pp. 121-125.

<sup>c</sup> Ztschr. Biol., 24 (1888), pp. 23-25.

<sup>d</sup> Sitzber. K. Akad. Wiss. [Vienna], Math. Naturw. Kl., 90 (1884), No. 3, p. 323.

<sup>e</sup> Preserved Food for Armies. Inaug. Diss., Univ. St. Petersb., 1886, pp. 94-98.

<sup>f</sup> The Composition of Salt Meat and the Assimilation of its Nitrogenous Constituents. Inaug. Diss., Univ. St. Petersb., 1886.

<sup>g</sup> Arch. Hyg., 27 (1896), p. 182.

<sup>h</sup> Der Nahrwert des Rindfleisches. Inaug. Diss., Univ. Berlin, 1897.

and pan broiling; and 6 were with veal, 3 with mutton, and 4 with pork, all roasted. The results of the experiments with beef show the effects of different methods of cooking upon the digestibility of the meat, and a comparison of the results with the various meats cooked in the same way shows the relative digestibility of different kinds of meat.

In all the experiments with simple diet a study was made of the amounts of metabolic nitrogen in the feces, and in all the 67 experiments the urine was collected and the balance of income and outgo of nitrogen was determined.

#### EXPERIMENTAL METHODS.

The methods followed in these experiments were similar to those described in former bulletins of this Office; hence a brief statement will suffice here. In general, the various food materials were eaten ad libitum, the amount of each article eaten being recorded and a sample reserved for analysis. The feces for the total experimental period were collected and analyzed. The digestibility of the nutrients of the total diet was determined from the quantity of each in the food and in the feces. In the experiments with simple diets the digestibility of the nutrients of the meat alone was computed from the data for the total diet by allowing for the digestible nutrients of the materials eaten with the meat, as explained in the description of such experiments (p. 26).

Aside from these general principles, however, the different groups of experiments recorded herein differed considerably in some details. Those details that pertain particularly to given experiments are therefore given in connection with the other data of the experiments. The different kinds of experiments included in the investigation are considered separately on the following pages. The data regarding composition of food material and feces for the natural digestion experiments are here tabulated.

#### COMPOSITION OF FOOD MATERIALS.

Samples of all the food materials used in the experiments were analyzed according to the usual methods, with such minor modifications as have been found expedient. Nitrogen was determined by the Kjeldahl method. Moisture was determined by heating the sample for sixteen hours at 104° C. in a current of hydrogen. Ether extraction by the Soxhlet method was continued for twenty-four hours in the case of meat and baked beans, for sixteen to twenty hours in the case of bread, breakfast food, and bananas, and for about twelve hours in the case of milk. The results of the analyses are given in Table 1.

TABLE I. Composition of food materials in natural digestion experiments here recorded.

Laboratory No.	Food material.	Used in experiment No.	Water.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
610	Beef, round, pan broiled.....	267-270	66.59	26.08	3.14	.....	3.82
613	.....do.....	267-270	66.60	26.31	3.04	.....	3.87
716	Beef, round, cooked in water 2 hours.....	271, 272	61.86	29.07	6.10	.....	3.46
718	.....do.....	271, 272	61.64	28.98	6.07	.....	3.30
739	Beef, round, cooked in water 4 hours.....	273, 274	63.92	25.97	7.52	.....	2.73
740	.....do.....	273, 274	63.77	26.15	7.56	.....	2.74
783	Beef, round, cooked in water 2 hours.....	275	56.98	35.71	4.97	.....	2.01
798	.....do.....	276	54.68	35.09	7.97	.....	1.82
809	.....do.....	277	53.73	36.13	7.51	.....	2.81
825	Beef, round, fried in butter.....	278	64.12	26.64	6.74	.....	2.28
839	.....do.....	279	64.83	26.07	5.72	.....	1.58
849	Beef, round, cooked in water 20 minutes.....	280	62.30	28.64	6.86	.....	1.67
861	.....do.....	281	60.71	32.61	5.25	.....	1.61
871	Beef, round, roasted.....	282	66.39	23.24	8.43	.....	1.31
884	.....do.....	283	62.96	27.97	7.18	.....	1.45
899	Beef, round, cooked in water.....	284	56.95	31.52	9.33	.....	2.16
925	.....do.....	285	55.99	31.64	9.77	.....	2.12
963	.....do.....	286	56.12	33.84	8.13	.....	1.82
988	.....do.....	287	56.97	34.37	6.08	.....	3.40
1029	.....do.....	288	58.96	32.48	6.53	.....	1.74
1054	.....do.....	289	57.87	35.06	5.54	.....	2.08
1108	.....do.....	291	62.10	30.16	5.75	.....	2.15
1131	.....do.....	293, 294	67.59	26.29	3.91	.....	1.76
1148	.....do.....	295, 296	56.72	34.35	7.11	.....	1.71
1216	.....do.....	298, 299	64.86	30.76	2.47	.....	1.62
1244	.....do.....	297-300, 301	68.45	27.42	2.34	.....	1.62
1116	.....do.....	291	60.07	33.80	4.07	.....	2.21
1107	Beef, round, raw.....	291	75.20	19.21	4.76	.....	1.00
1119	.....do.....	290-292	74.41	20.84	3.71	.....	1.05
1130	.....do.....	293, 294	76.54	20.68	1.97	.....	1.07
1287	Beef, shoulder, cooked in water.....	368-370	49.39	22.61	26.46	.....	1.60
1313	Beef, round, pan broiled.....	371-373	56.98	28.46	12.24	.....	2.58
1330	Beef, round, fried in lard.....	374-376	52.26	33.97	11.22	.....	2.58
1347	Beef, round, roasted.....	377-379	59.12	29.77	8.30	.....	3.20
1525	Beef, ribs, roasted.....	422, 423	44.43	20.08	34.09	.....	1.93
1561	.....do.....	426, 427	55.11	24.64	18.21	.....	2.55
1595	.....do.....	428	49.88	20.56	28.06	.....	2.37
1617	.....do.....	429, 430	43.51	23.63	30.67	.....	2.34
1406	Veal, leg, roasted.....	380-382, 383	53.17	28.12	16.56	.....	2.34
1469	.....do.....	419, 421	66.20	28.38	3.34	.....	2.47
1438	Mutton, leg, roasted.....	381, 384, 385	50.58	25.10	21.82	.....	2.89
1447	.....do.....	381, 384, 385	52.05	29.57	17.05	.....	2.45
1452	Pork, fresh ham, roasted.....	386, 387	47.09	31.82	20.04	.....	2.26
1546	.....do.....	421	53.02	25.13	20.24	.....	2.37
1560	.....do.....	425	54.65	26.10	16.27	.....	3.23
620	Butter.....	267, 268	8.67	.46	88.65	.....	2.22
621	.....do.....	267, 268	8.83	.70	88.39	.....	2.08
656	.....do.....	269, 270	8.55	.49	88.46	.....	2.50
657	.....do.....	269, 270	7.75	.48	89.58	.....	2.19
713	.....do.....	271, 272	9.03	.52	88.42	.....	2.03
741	.....do.....	273, 274	8.99	.56	88.47	.....	1.98
786	.....do.....	275	10.50	.69	86.61	.....	2.20
802	.....do.....	276	7.13	.80	90.74	.....	1.33
813	.....do.....	277	12.32	.40	84.55	.....	2.73
828	.....do.....	278	9.28	.38	88.29	.....	2.05
837	.....do.....	279	9.01	.54	87.39	.....	3.06
852	.....do.....	280	8.17	.60	89.03	.....	2.20
864	.....do.....	281	9.31	.56	88.80	.....	1.33
874	.....do.....	282	8.53	.64	89.75	.....	1.08
885	.....do.....	283	6.42	.81	90.32	.....	2.45
902	Butter, creamy.....	284, 285	11.94	.55	82.05	.....	5.46
964	.....do.....	286, 287	12.45	.52	82.65	.....	4.38
1032	.....do.....	288, 289	13.37	.56	81.07	.....	5.00
1123	.....do.....	290, 292	6.94	.81	91.70	.....	.55
1133	.....do.....	293, 294	6.40	.62	92.64	.....	.34
1150	.....do.....	295, 296	9.46	.60	89.22	.....	.72
1208	.....do.....	297, 301	11.42	.66	87.68	.....	.24
1286	.....do.....	368	6.82	.60	89.92	.....	2.66
1312	.....do.....	371, 374	8.75	.80	88.09	.....	2.36
1345	.....do.....	377	7.69	.47	89.45	.....	2.39
1407	Butter.....	382, 383	13.61	.82	82.69	.....	2.88
1436	.....do.....	384, 385	12.81	.79	83.22	.....	3.18
1451	.....do.....	386, 387	11.72	.55	85.62	.....	2.11
1468	.....do.....	420, 421	9.83	.55	88.00	.....	1.62
1526	.....do.....	422, 423	12.73	.55	84.35	.....	2.37
1549	.....do.....	424, 425	10.44	1.00	87.80	.....	1.09
1564	.....do.....	426, 427	11.02	.70	85.90	.....	2.38
1598	.....do.....	428	8.62	.67	88.33	.....	2.38
1620	.....do.....	429, 430	11.07	.82	86.09	.....	2.02
622	Milk.....	267, 268	86.92	3.21	4.34	4.80	.73

TABLE 1.—Composition of food materials in natural digestion experiments here recorded—  
Continued.

Laboratory No.	Food material.	Used in experiment No.—	Water.	Protein (N×6.25).	Fat.	Carbo-hydrates.	Ash.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
623	Milk	267, 268	86.92	3.27	4.37	4.80	0.64
670	do	269, 270	86.32	3.35	4.64	4.94	.75
723	do	271, 272	87.11	3.15	4.11	4.90	.73
746	do	273, 274	87.24	3.25	3.80	4.99	.72
789	do	275	86.62	3.55	4.33	4.74	.76
801	do	276	87.11	3.46	4.36	4.31	.76
812	do	277	88.37	2.67	3.37	4.84	.75
829	do	278	87.75	2.78	3.57	5.16	.74
838	do	279	87.59	2.79	4.21	4.70	.71
853	do	280	86.88	2.77	4.36	5.27	.72
865	do	281	86.90	3.04	4.74	4.60	.72
875	do	282	88.15	2.48	3.84	4.86	.69
886	do	283	87.72	2.63	3.83	5.13	.69
898	Milk, skim	284	91.25	3.13	.39	4.49	.74
927	do	284, 285	92.37	2.85	.42	3.70	.66
985	do	286	91.37	3.10	.19	4.62	.72
1031	do	288	91.41	3.03	.10	4.71	.75
928	Milk, whole	285	87.92	3.37	3.68	4.29	.74
990	do	287	87.92	3.23	3.76	4.38	.71
1057	do	289	88.20	3.08	3.65	4.33	.74
1117	do	291	89.18	3.01	2.94	4.18	.69
1151	do	295, 296	88.46	2.75	3.60	4.52	.67
1209	do	298, 299	88.60	3.04	3.18	4.48	.70
1232	do	300	88.53	2.83	3.37	4.61	.66
1234	do	294, 300, 301	87.64	3.16	3.93	4.58	.69
1285	do	368-370	87.37	2.74	4.17	5.04	.68
1301	do	369	89.33	2.28	2.79	4.93	.67
1311	do	371-373	87.83	2.70	4.31	4.50	.66
1329	do	374-376	87.46	2.86	4.25	4.60	.83
1346	do	377-379	87.14	2.89	4.16	5.06	.75
1405	Milk	380, 382, 383	86.00	3.47	5.35	4.76	.72
1429	do	380, 382, 383	87.69	3.04	3.86	4.74	.67
1435	do	381, 384, 385	87.81	3.26	3.69	4.51	.73
1449	do	386, 387	87.67	3.18	3.83	4.49	.83
1466	do	419-421	87.13	3.13	4.41	4.61	.72
1523	do	422, 423	86.02	3.25	5.71	4.37	.65
1547	do	424, 425	87.84	3.23	3.87	4.34	.72
1562	do	426, 427	87.30	3.00	4.42	4.58	.70
1597	do	428	87.29	3.02	4.16	4.87	.66
1619	do	429, 430	87.44	2.99	4.20	4.69	.68
614	Bread	267, 268	41.31	7.39	3.01	47.13	1.17
616	do	267, 268	37.78	7.77	3.14	50.10	1.21
617	do	267, 268	44.81	7.04	2.70	44.34	1.11
652	do	269, 270	39.02	8.09	2.48	49.28	1.13
655	do	269, 270	39.39	7.86	2.47	49.25	1.04
710	do	271, 272	39.37	7.92	2.35	49.37	.99
712	do	271, 272	40.20	7.77	2.42	48.62	.99
735	do	273, 274	38.80	7.98	3.46	48.85	.91
736	do	273, 274	38.80	7.90	3.34	49.04	.91
785	do	275	44.19	7.39	.89	46.67	.86
799	do	276	44.20	7.76	.48	46.27	1.29
810	do	277	44.37	7.53	1.36	46.91	.83
826	do	278	41.59	9.04	1.16	47.46	.75
840	do	279	42.55	8.40	1.11	47.14	.80
850	do	280	42.00	8.52	1.31	47.42	.75
862	do	281	41.42	8.06	.88	48.76	.88
872	do	282	44.84	8.30	.71	45.49	.66
882	do	283	42.53	8.76	.85	47.17	.69
901	Bread, white cream	284	43.41	8.26	.96	46.57	.80
924	do	285	44.17	8.12	.72	46.09	.89
962	do	286	44.15	8.39	.56	45.91	1.00
989	do	287	45.04	8.24	.46	45.34	.92
1030	do	288	43.52	8.76	1.00	45.69	1.03
1056	do	289	44.14	8.48	.70	45.94	.74
1109	do	290	45.58	7.47	.36	45.24	1.35
1122	do	291, 292	44.57	7.89	.38	46.34	.82
1132	do	293, 294	44.66	7.76	.38	46.51	.69
1149	do	295, 296	47.22	7.28	.16	44.65	.89
1207	do	297, 298	43.92	7.46	.74	47.05	.83
1233	do	299-301	45.62	7.20	.74	45.77	.67
1284	Bread, white	368-370	44.24	8.61	.88	45.39	.88
1327	do	371-373	42.23	9.34	.54	45.05	.84
1328	do	374-376	44.95	9.31	.27	44.64	.83
1344	do	377-379	43.52	9.41	.59	45.76	.72
1404	Bread	380-383	44.11	9.05	.39	45.59	.86
1437	do	381, 384, 385	44.07	9.08	.41	45.67	.77
1450	do	386, 387	43.08	9.15	.31	46.75	.71
1467	do	417, 420, 421	45.56	8.01	.40	45.21	.82

TABLE I.—*Composition of food materials in natural digestion experiments here recorded*  
Continued.

Laboratory No.	Food material.	Used in experiment No.	Water.	Protein (N×6.25).	Fat.	Carbo-hydrates.	Ash.
1524	Bread	422, 423	43.57	8.68	.40	46.48	0.87
1548	do	424, 425	43.97	8.39	.23	46.61	.80
1563	do	426, 427	43.27	9.26	.36	46.39	.72
1596	do	428	44.31	8.39	.38	45.96	.96
1618	do	429, 430	41.99	8.60	.79	47.78	.84
608	Breakfast food	267-274	9.93	11.32	1.02	77.31	.42
787	do	275	11.88	12.54	.94	74.43	.51
797	Rolled oats	275-283	8.82	14.51	7.24	67.61	1.82
897	Cream of wheat	284, 289	12.40	11.62	1.10	74.43	.45
624	Beans, baked	267, 268	67.42	7.61	2.33	20.17	2.40
625	do	267, 268	67.58	7.59	2.24	20.18	2.41
650	do	267-270	67.46	7.51	2.15	20.45	2.42
651	do	267-270	67.60	7.43	2.36	20.18	2.44
724	do	271, 272	68.86	7.50	2.21	19.13	2.30
747	do	273, 274	69.41	6.81	2.30	19.84	1.61
784	do	275	66.69	7.23	1.39	22.19	2.50
800	do	276	66.07	7.53	.94	22.95	2.51
811	do	277	66.17	7.34	1.18	22.61	2.70
827	do	278	66.03	7.43	1.97	22.06	2.51
841	do	279	66.97	6.97	1.46	21.91	2.69
851	do	280	67.34	6.96	1.53	22.03	2.15
863	do	281	65.14	7.40	1.06	23.29	2.64
873	do	282	66.22	7.54	.95	22.50	2.79
883	do	283	66.51	8.59	1.21	20.96	2.73
900	Beans, canned baked	284	70.25	6.56	2.04	19.46	1.69
923	do	285	70.30	6.57	1.84	19.69	1.61
961	do	286	69.68	6.56	2.04	19.58	2.13
987	do	287	67.34	7.49	1.15	21.43	2.58
1028	do	288	67.07	7.13	1.50	22.43	1.87
1055	do	289	67.06	7.47	1.46	21.61	2.40
626	Bananas	267	76.71	1.03	.06	21.43	.78
639	do	267	77.58	1.14	.07	20.45	.75
627	do	268	76.25	1.06	.07	21.78	.84
638	do	268					
669	do	270	77.96	1.07	.03	20.11	.83
668	do	269	78.35	1.06	.03	19.76	.80
722	do	271	76.41	1.05	.05	21.70	.77
721	do	272	76.98	1.10	.05	21.09	.78
744	do	274	77.62	1.19	.05	20.43	.71
745	do	273	77.76	1.19	.05	20.28	.72
926	do	284	79.32	.94	.09	18.92	.73
950	do	285	77.80	.89	.09	20.48	.74
986	do	286	78.68	1.01	.09	19.47	.75
1026	do	287	80.27	1.03	.14	17.93	.63
1053	do	288	79.73	.88	.11	18.57	.71
1088	do	289	78.04	1.15	.08	20.02	.71
609	Sugar	267-274				100.00	
609	do	280-283	1.35			99.65	
788	do	275-279				100.00	
896	do	284, 289	1.27	.04	.16	99.53	

#### COMPOSITION OF FECES.

Separation of the feces pertaining to a given experiment was made by means of lampblack, taken in gelatin capsules at the beginning and the end of the experimental period. The total quantity of feces for each experiment was dried and ground and the samples for analysis were weighed from the total material thus prepared. In the first 8 experiments the samples were analyzed in the water-free condition, but in all the others they were in the air-dry condition, the methods of analysis being the same as in the case of the foods. Extraction with ether was continued for twenty-four hours, but it was difficult in some cases to get satisfactory results in this determination owing,

no doubt, to the fact that the feces contain substances other than fat which are soluble in ether. The data regarding the composition of the feces are given in Table 2.

TABLE 2.—*Composition of feces in the digestion experiments here reported.*

Laboratory No.	Material.	From experiment No.—	Water.	Protein (N. × 6.25).	Fat.	Carbohydrates.	Ash.
758	Feces, water-free.	267	.....	34.71	14.17	36.29	14.83
759	do.	269	.....	34.63	13.15	37.82	14.40
760	do.	271	.....	34.08	13.19	38.81	13.92
761	do.	273	.....	34.20	13.66	36.70	15.34
762	do.	268	.....	25.83	7.71	45.99	20.48
763	do.	270	.....	26.53	11.14	42.88	19.45
764	do.	272	.....	27.82	9.81	42.53	19.84
765	do.	274	.....	36.94	10.28	41.64	21.13
794	Feces, air-dried.	275	6.21	37.77	10.71	28.00	17.31
807	do.	276	6.62	39.20	9.30	27.68	17.20
818	do.	277	7.26	36.30	12.21	26.61	17.62
834	do.	278	7.05	37.13	7.87	29.54	18.41
846	do.	279	7.71	37.12	10.27	27.59	17.31
858	do.	280	6.67	37.74	10.12	27.77	17.70
870	do.	281	7.46	40.46	11.44	23.52	17.12
880	do.	282	8.53	41.37	12.41	21.51	16.18
891	do.	283	9.12	43.00	11.25	21.09	15.54
991	do.	284	8.36	36.98	7.15	28.07	19.44
992	do.	285	10.83	34.72	10.29	26.91	17.25
993	do.	286	9.47	39.00	7.42	25.22	18.89
994	do.	287	9.05	28.25	7.77	28.34	16.59
1089	do.	288	9.00	28.88	7.76	26.80	17.56
1090	do.	289	10.55	36.86	6.80	30.09	15.70
1115	do.	291	6.82	28.00	12.32	38.05	14.81
1128	do.	290	10.48	39.51	10.96	28.55	10.50
1129	do.	292	8.42	33.98	13.83	28.43	15.34
1128	do.	293	9.59	38.82	8.67	32.37	10.55
1139	do.	294	6.89	26.04	11.00	38.64	16.83
1156	do.	295	7.12	28.24	12.05	38.73	13.86
1157	do.	296	7.30	27.55	15.46	29.30	20.39
1223	do.	297	8.40	27.42	12.28	28.59	21.31
1227	do.	298	12.20	29.26	9.15	16.49	12.30
1231	do.	299	7.47	22.49	9.25	38.37	21.92
1248	do.	300	16.19	28.20	17.05	6.66	31.90
1252	do.	301	14.23	29.78	10.72	23.77	21.50
1291	do.	308	9.08	24.64	12.22	33.66	19.40
1295	do.	369	15.39	27.67	23.86	8.63	24.45
1299	do.	370	13.82	20.15	22.16	21.23	12.64
1318	do.	371	8.46	29.99	8.47	28.92	24.16
1322	do.	372	12.71	34.95	8.87	14.21	20.26
1326	do.	373	7.90	27.42	10.87	30.23	23.58
1335	do.	374	8.75	28.50	6.93	29.91	25.91
1339	do.	375	11.87	30.40	9.03	18.05	30.65
1343	do.	376	8.27	21.02	6.55	37.82	26.34
1352	do.	377	9.85	28.47	5.76	30.96	24.96
1356	do.	378	13.64	30.86	7.59	15.39	32.52
1360	do.	379	8.63	22.76	6.26	35.97	26.38
1411	do.	380	11.62	40.41	8.81	21.81	17.25
1415	do.	381	12.90	32.03	8.73	31.04	15.70
1419	do.	382	10.33	38.12	9.56	27.92	14.07
1423	do.	383	6.98	28.81	9.70	36.80	17.71
1442	do.	384	13.30	20.57	9.49	32.42	14.22
1446	do.	385	4.63	21.32	9.92	45.77	18.36
1456	do.	386	7.95	32.23	11.07	28.45	20.70
1460	do.	387	6.06	23.82	8.36	41.39	20.37
1473	do.	419	8.66	33.45	11.81	18.03	28.05
1477	do.	420	7.33	24.92	11.64	28.43	17.68
1481	do.	421	6.52	21.97	10.35	40.95	20.21
1530	do.	422	8.87	21.23	12.30	41.08	16.52
1534	do.	423	6.95	18.12	10.69	45.64	18.60
1553	do.	424	8.63	29.95	10.76	32.15	18.51
1557	do.	425	7.75	30.98	9.37	30.23	21.67
1568	do.	426	6.64	17.84	7.56	48.44	19.52
1572	do.	427	7.91	24.91	9.92	38.26	19.00
1602	do.	428	9.13	26.23	10.25	39.31	15.08
1624	do.	429	7.83	29.60	10.07	36.63	15.87
1628	do.	430	8.68	35.27	10.52	27.70	17.83

## DETAILS OF EXPERIMENTS WITH MIXED DIET, INCLUDING MEAT.

As previously suggested, one of the objects of the digestion experiments here reported was to determine what influence different methods of cooking meat would have upon the digestibility of the total diet in which the meat was eaten. For this purpose 23 experiments were made in connection with the investigations conducted during 1898–1901 in which meat cooked in different ways constituted part of a mixed diet that included several common food materials.

In selecting a diet for these experiments the problem was to obtain a ration containing such a variety of food materials that it would fairly represent an average mixed diet and be sufficiently palatable to be eaten for several days, but which should not include so many different kinds of food that the number of analyses would be unduly large. The foods selected were bread, butter, sugar, milk, rolled oats or wheat breakfast food, beans, and bananas, in addition to the meat. The diet made up of these materials proved quite satisfactory for all four subjects throughout all the tests.

The 23 experiments here considered were all alike in that the diet consisted of the same kinds of food materials, but they differed somewhat in respect to the control of the quantity of food eaten and of the muscular activity of the subjects, and so the experiments have been arranged in three groups, in accordance with these variations.

### EXPERIMENTS WITH AMOUNTS OF FOOD NOT RESTRICTED.

This group includes 8 experiments. The subjects were two young men, designated as A and B. Subject A was 35 years old and weighed, in ordinary clothing, about 170 pounds; subject B was 23 years old and weighed about 135 pounds. They were both in good health, had good appetites and apparently normal digestion. Both were chemists, and during the time of the experiments were engaged in their ordinary duties in the laboratory.

Four experiments were made with each subject, in each case the corresponding experiments with the two subjects being carried on simultaneously. The daily food in the experiments consisted of a mixed diet of the materials mentioned above. The food materials were obtained as needed, and from each fresh portion a sample was reserved for analysis. The same kind and cut of meat, beef round, was used in every case, but it was differently cooked, as explained below. No attempt was made to regulate the quantities consumed, the subjects being allowed to eat at each meal according to their desires for the selected foods. There were noticeable differences in the amounts of the different foods eaten by the two subjects in corresponding experiments and by the same subject in different experiments.

Experiment No. 267, with subject A, and No. 268, with subject B, began with breakfast July 5, 1899, and continued four days (12

meals). Without any intermission between the two periods experiment No. 269, with subject A, and No. 270, with subject B, began with breakfast July 9, 1899, and continued three days (9 meals). The meat eaten in each experiment was beef round pan broiled (fried without added fat) for fifteen minutes.

Experiments Nos. 271 and 272, with subjects A and B, respectively, began with breakfast July 19, 1899, and continued four days (12 meals). In cooking the meat eaten in these two experiments it was placed in boiling water, and the temperature of the water was then maintained at 80° C. for two hours.

Experiments Nos. 273 and 274, with subjects A and B, respectively, began with breakfast July 26, 1899, and continued four days (12 meals). The meat in this case was placed in cold water, which was then heated and maintained at 65° to 70° C. for four hours.

The data regarding the digestibility of the diets in these experiments are given in Table 3.

TABLE 3.—*Results of digestion experiments Nos. 267-274.*

Laboratory No.		Weight of mate- rial.	Total or- ganic matter.	Protein (N×6.25).	Fat.	Carbo- hydrates.	Ash.
<i>Experiment No. 267, subject A.</i>							
609	Sugar.....	220	220	.....	.....	220	.....
620, 621	Butter.....	220	196	1	195	.....	5
622, 623	Milk.....	1,633	202	53	71	78	11
614, 616, 617	Bread.....	715	411	53	21	337	8
624, 625, 650, 651	Baked beans.....	895	269	68	20	181	22
626, 639	Bananas.....	1,200	265	13	1	251	9
608	Breakfast food.....	140	125	16	1	108	1
610-613	Meat.....	360	106	95	11	.....	14
Total diet.....		5,383	1,796	299	320	1,175	70
758	Feces.....	77	65	27	11	28	11
Amount digested.....		1,731	272	309	1,147	59	—
Per cent digested.....		96	91	96	98	98	84
<i>Experiment No. 268, subject B.</i>							
609	Sugar.....	60	60	.....	60	.....	—
620, 621	Butter.....	240	213	1	212	.....	5
622, 623	Milk.....	4,916	609	159	214	236	34
614, 616, 617	Bread.....	585	336	43	17	276	7
624, 625, 650, 651	Baked beans.....	761	228	57	17	154	18
627, 638	Bananas.....	1,200	270	13	1	256	10
608	Breakfast food.....	140	125	16	1	108	1
610-613	Meat.....	410	121	108	13	.....	16
Total diet.....		8,312	1,962	397	475	1,090	91
762	Feces.....	109	86	28	8	50	22
Amount digested.....		1,876	369	467	1,040	69	—
Per cent digested.....		96	93	98	95	95	75
<i>Experiment No. 269, subject A.</i>							
609	Sugar.....	160	160	.....	160	.....	—
656, 657	Butter.....	165	148	1	147	.....	4
670	Milk.....	1,175	152	39	55	58	9
652, 655	Bread.....	525	313	41	13	259	6
650, 651	Baked beans.....	600	180	45	13	122	14
668	Bananas.....	850	177	9	.....	168	9
608	Breakfast food.....	105	94	12	1	81	—
610-613	Meat.....	260	77	69	8	.....	10
Total diet.....		3,840	1,301	216	237	848	52
759	Feces.....	53	46	18	7	20	8
Amount digested.....		1,255	198	230	828	44	—
Per cent digested.....		96	92	97	97	95	85

TABLE 3.—*Results of digestion experiments Nos. 267-274—Continued.*

Laboratory No.		Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 270, subject R.</i>							
609	Sugar.....	45	45	.....	.....	45	.....
656, 657	Butter.....	180	161	1	160	.....	4
670	Milk.....	3,716	479	124	172	183	28
652, 655	Bread.....	450	269	36	11	222	5
650, 651	Baked beans.....	500	150	37	11	102	12
669	Bananas.....	850	180	9	.....	171	7
608	Breakfast food.....	105	94	12	1	81	11
610-613	Meat.....	300	88	79	9	.....	12
	Total diet.....	6,146	1,466	298	364	804	68
763	Feces.....	77	62	20	9	33	15
	Amount digested.....	1,404	278	355	771	53	
	Per cent digested.....	96	93	98	96	78	
<i>Experiment No. 271, subject T.</i>							
609	Sugar.....	240	240	.....	.....	240	.....
713	Butter.....	220	195	1	194	.....	4
723	Milk.....	1,500	182	47	62	73	11
710, 712	Bread.....	700	413	55	17	341	7
724	Baked beans.....	960	277	72	21	184	22
722	Bananas.....	1,400	320	45	1	304	11
608	Breakfast food.....	140	125	16	1	108	1
716-718	Meat.....	400	140	116	24	.....	14
	Total diet.....	5,360	1,892	322	320	1,250	70
760	Feces.....	78	67	27	10	30	11
	Amount digested.....	1,825	295	310	1,220	59	
	Per cent digested.....	96	92	97	98	84	
<i>Experiment No. 272, subject P.</i>							
609	Sugar.....	60	60	.....	.....	60	.....
713	Butter.....	180	160	1	159	.....	4
723	Milk.....	4,800	583	151	197	235	35
710, 712	Bread.....	560	330	44	13	273	5
724	Baked beans.....	800	231	60	18	153	18
721	Bananas.....	1,400	311	45	1	295	11
608	Breakfast food.....	140	125	16	1	108	1
716, 718	Meat.....	440	155	128	27	.....	15
	Total diet.....	8,380	1,955	415	416	1,124	89
764	Feces.....	70	56	20	7	30	14
	Amount digested.....	1,899	395	409	1,094	75	
	Percent digested.....	97	95	98	97	84	
<i>Experiment No. 273, subject A.</i>							
609	Sugar.....	24	24	.....	.....	24	.....
741	Butter.....	220	196	1	195	.....	4
746	Milk.....	4,500	181	49	57	75	11
735, 736	Bread.....	710	428	56	24	348	6
747	Baked beans.....	960	277	65	22	190	16
745	Bananas.....	1,400	302	47	1	284	10
608	Breakfast food.....	140	125	16	1	108	1
739, 740	Meat.....	400	134	104	30	.....	11
	Total diet.....	5,354	1,667	308	330	1,029	59
761	Feces.....	51	43	17	7	19	8
	Amount digested.....	1,624	291	323	1,010	51	
	Per cent digested.....	97	94	98	98	87	
<i>Experiment No. 274, subject R.</i>							
609	Sugar.....	60	60	.....	.....	60	.....
741	Butter.....	180	160	1	159	.....	4
746	Milk.....	4,800	578	156	183	239	34
735, 736	Bread.....	560	338	45	19	274	5
747	Baked beans.....	800	231	54	18	159	13
744	Bananas.....	1,400	304	47	1	286	10
608	Breakfast food.....	140	125	16	1	108	1
739, 740	Meat.....	440	147	114	33	.....	12
	Total diet.....	8,380	1,943	403	414	1,126	79
765	Feces.....	63	49	17	6	26	13
	Amount digested.....	1,895	386	408	1,100	66	
	Per cent digested.....	97	96	98	98	83	

The results of the foregoing experiments are summarized in Table 4.

TABLE 4.—*Summary of results of digestion experiments Nos. 267-274.*

Experiment No.	Subject.	Diet.	Coefficients of digestibility.				
			Total organic matter.	Protein.	Fat.	Carbohydrates.	Ash.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
267	A	Mixed diet, meat pan broiled.....	96	91	97	98	84
269	A	.....do.....	96	92	97	97	85
		Average.....	96	91	97	97	85
268	B	Mixed diet, meat pan broiled.....	96	93	98	95	75
270	B	.....do.....	96	93	98	96	78
		Average.....	96	93	98	95	77
		Average 4 experiments with A and B.....	96	92	97	96	81
271	A	Mixed diet, meat cooked in water at 80° C.....	96	92	97	98	84
272	B	.....do.....	97	95	98	97	84
		Average.....	96	93	97	97	84
273	A	Mixed diet, meat cooked in water at 65-70° C.....	97	94	98	98	87
274	B	.....do.....	97	96	98	98	83
		Average.....	97	95	98	98	85

There was striking uniformity in the digestibility of the total organic matter of the diets containing beef cooked in different ways. In five experiments it was 96 per cent, and in three it was 97 per cent, showing that the diet as a whole was quite thoroughly digested in each case. In respect to the different nutrients also, the digestion of each was thorough and the agreement of results in the various experiments was satisfactory indeed. The indications are that under the conditions of these experiments the different methods of cooking the meat had no influence upon the digestibility of the diet as a whole. Possibly the amount of meat eaten was too small in proportion to that of the other materials to have much influence on the whole diet, though it will be noticed that in the majority of the experiments it furnished about a third of the total protein of the diet.

#### EXPERIMENTS WITH DEFINITE AMOUNTS OF FOOD AND OF UNIFORM MUSCULAR EXERCISE.

In these experiments the attempt was made to control the conditions in such manner that, as nearly as possible, the only variation between the different experiments was in the method of cooking the meat. The same subject served throughout the whole series, and, except that the meat used was cooked in different ways, all the details, such as kinds and quantities of food consumed, daily routine of the subject, amount of exercise taken, etc., which it was believed might have some influence upon the general results, were maintained as

uniform as possible in the different experiments. It seemed fair to assume that under such conditions whatever differences were found in the results of the experiments would be due in large part to variations in digestibility of the meat brought about by different methods of cooking.

The subject in these experiments was a young man in good health and with apparently normal digestion. He was a chemist, and was engaged in his ordinary duties in the laboratory, but kept his work as nearly as he could the same from day to day, and in addition he took a given amount of physical exercise regularly each day during an experiment. His weight in ordinary clothing was about 136 pounds.

Nine experiments were made, each of four days' (12 meals) duration. There was in each case a period of several days between the end of one experiment and the beginning of the next. The chief purpose of the first experiment, which was considered as preliminary to the series, was to allow the subject opportunity to decide what kinds and quantities of food materials were most agreeable. The diet selected consisted of meat, bread, butter, sugar, beans, rolled oats, and milk. The meat used in all the experiments was lean beef round, cooked in different ways, as explained below. When eaten it was seasoned with salt and pepper.

The same amount of each food material was eaten in all the experiments in the series proper. The diet in the preliminary test differs slightly from that in the others, the quantity of beans being a little larger and that of bread a little smaller, while wheat breakfast food was eaten in place of rolled oats. The actual difference in the diet was so small, however, that the results of this test may be taken into account with those of the remaining experiments. As during the preceding experiments, the food materials were obtained as wanted in each test and sampled when used.

The preliminary experiment, No. 275, began with breakfast December 21, 1899. In cooking the meat used it was placed in boiling water, and the temperature of the water was then kept at 80° C. for two hours. Experiment No. 276 began with breakfast January 3, 1900. The meat used was cooked in the same way as in experiment No. 275. Experiment No. 277, which was a duplicate of No. 276, began with breakfast January 23, 1900.

Experiment No. 278 began with breakfast February 20, 1900. The meat used in this test was passed three times through a sausage mill, then made into balls and cooked by frying about ten minutes in a little melted butter, until medium well done. Experiment No. 279, which was a duplicate of experiment No. 278, began with breakfast March 12, 1900.

Experiment No. 280 began with breakfast March 26, 1900. The meat used was placed in boiling water and then cooked twenty

minutes at 80° C. The cooked beef was juicy and underdone, but tough. Experiment No. 281, a duplicate of No. 280, began with breakfast April 9, 1900.

Experiment No. 282 began with breakfast April 23, 1900. The meat used was cooked by roasting or broiling a large piece, first searing the surface for two or three minutes, then cooking for about twenty minutes, until medium well done. Experiment No. 283, a duplicate of No. 282, began with breakfast May 8, 1900.

The data of these experiments are given in Table 5.

TABLE 5.—*Results of digestion experiments Nos. 275-283.*

Laboratory No.	Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 275.</i>						
788 Sugar.....	120	120	.....	.....	120	.....
786 Butter.....	180	157	1	156	.....	4
789 Milk.....	2,486	314	88	108	118	19
787 Breakfast food.....	140	123	18	1	104	1
784 Beans.....	880	271	64	12	195	22
785 Bread.....	780	428	57	7	364	6
783 Beef.....	400	163	143	20	.....	8
Total diet.....	4,986	1,576	371	304	901	60
Feces (air dried).....	58	44	22	6	16	10
Amount digested.....	1,532	349	298	885	50	
Per cent digested.....	97	94	98	98	83	
<i>Experiment No. 276.</i>						
788 Sugar.....	120	120	.....	.....	120	.....
802 Butter.....	180	165	2	163	.....	2
801 Milk.....	2,486	301	86	108	107	19
797 Rolled oats.....	140	125	20	10	95	3
800 Beans.....	840	263	63	8	192	21
799 Bread.....	840	458	65	4	389	11
798 Beef.....	400	172	140	32	.....	7
Salt.....	8	.....	.....	.....	.....	8
Total diet.....	5,014	1,604	376	325	903	71
Feces.....	76	58	30	7	21	13
Amount digested.....	1,546	346	318	882	58	
Per cent digested.....	96	92	98	98	81	
<i>Experiment No. 277.</i>						
788 Sugar.....	120	120	.....	.....	120	.....
813 Butter.....	180	153	1	152	.....	5
812 Milk.....	2,484	270	66	84	120	18
797 Rolled oats.....	140	125	20	10	95	3
811 Beans.....	840	261	61	10	190	23
810 Bread.....	840	467	63	11	393	7
809 Beef.....	400	175	145	30	.....	11
Salt.....	7	.....	.....	.....	.....	7
Total diet.....	5,011	1,571	356	297	918	74
Feces.....	43	32	16	5	11	8
Amount digested.....	1,539	340	292	907	66	
Per cent digested.....	98	96	98	99	90	
<i>Experiment No. 278.</i>						
788 Sugar.....	120	120	.....	.....	120	.....
828 Butter.....	180	160	1	159	.....	4
829 Milk.....	2,484	285	68	89	128	18
797 Rolled oats.....	140	125	20	10	95	3
827 Beans.....	840	264	62	17	185	21
826 Bread.....	840	485	76	10	399	6
825 Beef.....	400	134	107	27	.....	9
Salt.....	9	.....	.....	.....	.....	9
Total diet.....	5,013	1,573	334	312	927	70
Feces.....	34	26	13	3	10	5
Amount digested.....	1,547	321	307	917	65	
Per cent digested.....	98	96	99	99	93	

TABLE 5. *Results of digestion experiments Nos. 275-283—Continued.*

Laboratory No.	Weight of material.	Total organic matter.	Protein (N × 6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 279.</i>						
788 Sugar.....	120	120	.....	.....	120	.....
837 Butter.....	180	158	1	157	.....	5
838 Milk.....	2,480	295	73	105	117	17
797 Rolled oats.....	140	125	20	10	95	3
841 Beans.....	840	255	59	12	184	23
840 Bread.....	840	476	71	9	396	7
839 Beef.....	400	127	104	23	.....	6
Salt.....	9	.....	.....	.....	.....	9
Total diet.....	5,009	1,556	328	316	912	70
Feces.....	27	21	10	3	9	5
Amount digested.....	.....	1,535	318	313	903	65
Per cent digested.....	.....	98	97	99	99	93
<i>Experiment No. 280.</i>						
609 Sugar.....	120	120	.....	.....	120	.....
852 Butter.....	180	161	1	160	.....	4
853 Milk.....	2,482	296	69	108	121	18
797 Rolled oats.....	140	125	20	10	95	3
851 Beans.....	840	256	58	13	185	18
850 Bread.....	840	480	72	11	398	6
849 Beef.....	400	142	115	27	.....	6
Salt.....	8	.....	.....	.....	.....	8
Total diet.....	5,009	1,583	325	329	919	63
Feces.....	49	37	18	5	14	9
Amount digested.....	.....	1,546	317	324	905	54
Per cent digested.....	.....	98	94	98	98	86
<i>Experiment No. 281.</i>						
609 Sugar.....	120	120	.....	.....	120	.....
864 Butter.....	180	161	1	160	.....	2
865 Milk.....	2,480	307	75	118	114	18
797 Rolled oats.....	140	125	20	10	95	3
863 Beans.....	840	494	62	9	423	22
862 Bread.....	840	485	68	7	410	7
861 Beef.....	400	151	130	21	.....	6
Salt.....	7	.....	.....	.....	.....	7
Total diet.....	5,007	1,843	256	325	1,162	65
Feces.....	27	20	11	3	6	5
Amount digested.....	.....	1,823	345	322	1,156	60
Per cent digested.....	.....	99	97	99	99	93
<i>Experiment No. 282.</i>						
609 Sugar.....	120	120	.....	.....	120	.....
874 Butter.....	180	163	1	162	.....	2
875 Milk.....	2,478	277	62	95	120	17
797 Rolled oats.....	140	125	20	10	95	3
873 Beans.....	840	260	63	8	189	23
872 Bread.....	840	458	70	6	382	6
871 Beef.....	400	127	93	34	.....	5
Salt.....	8	.....	.....	.....	.....	8
Total diet.....	5,006	1,530	209	315	906	64
Feces.....	50	38	21	6	11	8
Amount digested.....	.....	1,492	288	309	895	56
Per cent digested.....	.....	97	93	98	99	87
<i>Experiment No. 283.</i>						
609 Sugar.....	120	120	.....	.....	120	.....
885 Butter.....	180	164	1	163	.....	4
886 Milk.....	2,482	287	65	95	127	17
797 Rolled oats.....	140	125	20	10	95	3
883 Beans.....	840	260	74	10	176	23
882 Bread.....	840	479	76	7	396	6
884 Beef.....	400	141	112	29	.....	6
Salt.....	11	.....	.....	.....	.....	11
Total diet.....	5,013	1,576	348	314	914	70
Feces.....	49	37	21	6	10	8
Amount digested.....	.....	1,539	327	308	904	62
Per cent digested.....	.....	98	94	98	99	89

The results of this series of experiments, including the preliminary test, are summarized in Table 6.

TABLE 6.—*Summary of results of digestion experiments Nos. 275-283.*

Ex- periment No.	Diet.	Total organic matter.	Coefficients of digestibility.			
			Protein.	Fat.	Carbohy- drates.	Ash.
275	Mixed diet, meat cooked in water, well done.	97	94	98	98	83
276	do.....	96	92	98	98	81
277	do.....	98	96	98	99	90
	Average.....	97	94	98	98	85
280	Mixed diet, meat cooked in water, underdone	98	94	98	98	86
281	do.....	99	97	99	99	93
	Average.....	98	96	99	99	90
278	Mixed diet, meat chopped and fried.....	98	96	99	99	93
279	do.....	98	97	99	99	93
	Average.....	98	96	99	99	93
282	Mixed diet, meat roasted.....	97	93	98	99	87
283	do.....	98	94	98	99	89
	Average.....	97	93	98	99	88

As in the previous series, the diet as a whole in these experiments was uniformly quite thoroughly digested; and whether individual experiments or averages are considered, the variations in the results for the different nutrients are insignificant. The indications are that with this subject, under the conditions of the experiments, which though controlled were believed to be normal, differences in the method of cooking the meat had no effect upon the thoroughness of digestion of the diet in which it was eaten.

#### EXPERIMENTS WITH VARYING AMOUNTS OF FOOD AND OF MUSCULAR EXERCISE.

In the experiments of the preceding series the conditions in each case, even including the muscular activity of the subject, were maintained as nearly as possible the same as in all the others, with the exception of the one, the effect of the variation of which it was desired to investigate, namely, the method of cooking the meat. In the following experiments an attempt was made to learn whether variation in the amount of muscular exercise would have any effect upon the digestibility of the diet.

The data are here given as 6 digestion experiments. There were, however, in reality 3 experiments, each of which was divided into two consecutive periods, in which the conditions were the same except that in the first period the subject abstained as entirely as possible from exercise of any kind, whereas in the second period he performed a considerable amount of muscular work. The diet in both periods con-

sisted of the same kinds of food materials, except that skimmed milk was used in some periods and whole milk in others. The amounts of the different materials used in the two periods were so regulated that the quantity of protein per day was practically the same in the second period as in the first, but the quantity of energy was increased because of the work performed.

Each of the 6 experiments continued four days (12 meals), except that No. 286 continued four and one-third days (13 meals). The subject in all the experiments was a university student (C. A. S.), 21 years old, weighing without clothing a little over 140 pounds. The food consisted of a mixed diet containing meat cooked in every case by placing it in boiling water and then maintaining the temperature of the water at 80° to 85° C. for two hours. Instead of obtaining the food materials as wanted—as was done in the previous experiments—most of them were prepared at the beginning of each pair of experiments in quantities sufficient to last throughout both periods.

*Preparation of food.*—In all the experiments the meat used was the best beef round, cooked in water as stated above. In preparing it for consumption the cooked meat was removed from the water, and after draining and cooling was ground in a sausage mill, in order that a representative sample might be obtained for analysis. The ground meat was then seasoned with salt and pepper, and passed twice more through the sausage mill, after which it was put immediately into glass jars, sterilized for one hour at 95° C., and placed in a refrigerator until needed. The sample for analysis was taken while the meat was being put into the jars; this was dried in a water bath at 70° to 90° C. for about forty-eight hours, and then exposed as usual to room temperature and moisture before weighing again. When weighed the sample was finely ground for analysis.

The bread used in the experiments (known locally as "Cream White") was broken into fragments and sealed in tared glass fruit jars, weighed, sterilized at 95° C. for one hour and then placed in a refrigerator until wanted. The crust of the loaf was removed and only the crumb was used, as it was hoped thereby to get a more uniform and representative sample for analysis. The sample was taken at the time the pieces of bread were put into the jars, and was prepared for analysis in the same manner as the meat described above.

Creamery butter, purchased from one of the local grocers, was used. It was made into 1-ounce pats, which were put upon plates to drain and kept in the refrigerator over night; one half of each pat was removed, and all these were mixed into a composite sample for analysis; the remaining portions of the pats were placed in small glass jars, weighed, and kept in the refrigerator until used.

The mixed milk of a considerable number of cows was delivered from the University dairy as needed. The milk was found to be

always so well mixed that it was necessary to analyze only one sample for each experiment.

Sugar and wheat breakfast food (one of the common commercial sorts) were weighed from a bulk of each as needed. The wheat breakfast food for each meal was cooked by steaming.

The bananas used were bought each day as needed. One-half of each banana used was placed in a glass jar containing a little formalin, and at the end of the experiment the whole composite sample thus formed was thoroughly mixed by grinding in a mortar. A large portion of the mixed mass was dried and ground for analysis.

Canned baked beans were used, the contents of a number of cans being thoroughly mixed, then sealed in glass jars, and sterilized for one hour at 95° C. The jars were then placed in a refrigerator and kept until used. A sample for analysis was reserved from the mixed mass as it was being put into the jars. This was prepared in the same manner as the sample of meat described above.

The sterilized foods were preserved in good condition in the refrigerator, and the subject selected the weighed jars as he needed them. The meat was warmed before using by steaming for fifteen minutes. The milk also was sometimes heated to 40° to 50°, according to taste. If any food remained in a jar at the close of the experiment it was weighed again and the amount deducted from the total.

It was believed that to prepare the foods in the manner described gave better results than to weigh the food as needed from time to time, since errors in weighing that would result from loss of water occurring when food materials are kept exposed to the air would be prevented. Furthermore, it reduced the number of analyses considerably.

*Separation of feces.*—The supper preceding the first meal of the first experiment and the breakfast following the last meal of the second experiment of each pair consisted of milk, with occasionally a little bread and butter, and with each of these meals lampblack in a gelatin capsule was taken. This gave blackened feces of a characteristic consistency preceding and following the feces pertaining to the experimental diet. It was assumed that none of the feces colored by the lampblack taken at these periods would pertain to the experimental diet. For separating the feces for the first period from those for the second, the lampblack was taken after supper of the last meal of the first period.

The urine in these experiments was collected in 6-hour periods, beginning with 7 o'clock on the morning of the first day of each experiment.

Experiment No. 284 began with breakfast July 7, 1900. For the four days of this period the subject refrained as completely as practicable from muscular exertion of any sort. Without intermission

experiment No. 285 began with breakfast July 11, 1900. During this period the subject was engaged for eight hours each day riding a bicycle over paved streets. The work involved in this exercise was harder than that to which he had previously been accustomed.

Experiment No. 286 began with breakfast July 21, 1900. The subject remained as quiet as practicable during the period. Experiment No. 287, following No. 286 without intermission, began with dinner July 25, 1900. The subject worked eight hours each day on a stationary bicycle. This work seemed to be even harder for him than that performed in experiment No. 285.

Experiment No. 288 began with breakfast August 4, 1900. The subject did no actual work, but remained as quiet as practicable. In experiment No. 289, which began with breakfast August 8, 1900, the subject was at work eight hours each day on the stationary bicycle. The work during this period did not seem as hard for him as that performed in experiment No. 287.

The data of these six experiments are given in Table 7.

TABLE 7. *Results of digestion experiments Nos. 284-289.*

Laboratory No.		Weight of material.	Total organic matter.	Protein (N × 6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 284.</i>							
896	Sugar.....	80	80			80	
902	Butter.....	120	99	1	98		7
928	Skim milk.....	5,805	465	182	23	260	43
927	do .....	822	57	23	4	30	5
901	Bread.....	640	357	53	6	298	5
899	Meat.....	380	155	120	35		8
926	Bananas.....	1,200	239	11	1	227	9
897	Breakfast food.....	280	244	33	3	208	1
900	Baked beans.....	700	196	46	14	136	12
	Total diet.....	10,027	1,892	469	184	1,239	90
991	Feces.....	126	91	47	9	35	25
	Amount digested.....		1,801	422	175	1,204	65
	Per cent digested.....		95	90	95	97	73
<i>Experiment No. 285.</i>							
896	Sugar.....	160	159			159	
902	Butter.....	200	165	1	164		11
928	Whole milk.....	3,418	388	115	126	147	25
927	Skim milk.....	140	10	4	1	5	1
924	Bread.....	820	450	66	6	378	7
925	Meat.....	540	224	171	53		12
950	Bananas.....	1,600	343	14	1	328	12
897	Breakfast food.....	280	244	33	3	208	1
923	Baked beans.....	900	253	59	17	177	15
	Total diet.....	8,058	2,236	463	371	1,402	84
992	Feces.....	86	62	30	9	23	15
	Amount digested.....		2,174	433	362	1,379	69
	Percent digested.....		97	93	98	98	82
<i>Experiment No. 286.</i>							
896	Sugar.....	90	90			90	
964	Butter.....	130	108	1	107		6
985	Skim milk.....	7,190	509	223	14	332	52
962	Bread.....	600	370	58	4	317	7
963	Meat.....	405	170	137	33		7
986	Bananas.....	1,350	278	14	1	263	10
897	Breakfast food.....	320	279	37	4	238	1
961	Baked beans.....	700	197	46	14	137	15
	Total diet.....	10,875	2,070	516	177	1,377	98
993	Feces.....	109	79	43	8	28	21
	Amount digested.....		1,991	473	169	1,349	77
	Per cent digested.....		96	92	95	98	79

TABLE 7.—*Results of digestion experiments Nos. 284–289—Continued.*

Laboratory No.	Weight of material.	Total organic matter.	Protein. (N × 6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 287.</i>						
896 Sugar.....	160	159	.....	.....	159	.....
964 Butter.....	200	166	1	165	.....	9
990 Whole milk.....	5,069	576	164	190	222	36
989 Bread.....	780	422	64	4	354	7
988 Meat.....	420	170	144	26	.....	14
1026 Bananas.....	1,600	306	17	2	287	10
897 Breakfast food.....	280	244	33	3	208	1
987 Baked beans.....	800	241	60	9	171	21
Total diet.....	9,309	2,284	483	399	1,402	98
Feces.....	128	95	49	10	36	21
Amount digested.....	.....	2,189	434	389	1,366	77
Percent digested.....	.....	96	90	97	97	78
<i>Experiment No. 288.</i>						
896 Sugar.....	80	80	.....	.....	80	.....
1032 Butter.....	120	98	1	97	.....	9
1031 Skin milk.....	4,982	391	151	5	235	31
1030 Bread.....	640	354	56	6	291	2
1029 Meat.....	350	147	122	1	.....	.....
1053 Bananas.....	1,200	235	11	1	.....	.....
897 Breakfast food.....	280	244	33	3	208	1
1028 Baked beans.....	700	217	50	10	157	1
Total diet.....	8,382	1,766	424	147	1,195	.....
Feces.....	94	69	37	7	25	.....
Amount digested.....	.....	1,097	387	140	1,170	62
Percent digested.....	.....	96	91	95	98	79
<i>Experiment No. 289.</i>						
896 Sugar.....	160	159	.....	.....	159	.....
1032 Butter.....	200	163	1	162	.....	10
1057 Whole milk.....	3,316	367	102	121	144	25
1056 Bread.....	780	430	66	6	358	6
1054 Meat.....	420	170	147	23	.....	9
1088 Bananas.....	1,600	339	18	1	320	11
897 Breakfast food.....	280	244	33	3	208	1
1055 Baked beans.....	800	245	60	12	173	19
Total diet.....	7,555	2,117	427	328	1,362	81
Feces.....	92	68	34	6	28	14
Amount digested.....	.....	2,049	393	322	1,334	67
Percent digested.....	.....	97	92	98	98	82

The results of these 6 experiments are summarized in Table 8.

TABLE 8.—*Summary of results of digestion experiments Nos. 284–289.*

Experiment No.	Kind of experiment.	Total organic matter.	Coefficients of digestibility.			
			Protein.	Fat.	Carbohydrates.	Ash.
			Percent.	Percent.	Percent.	Percent.
284 Rest experiments.....	.....	95	90	95	97	73
286 .....do.....	.....	96	92	95	98	79
288 .....do.....	.....	96	91	95	98	79
Average.....	.....	96	91	95	98	77
285 Work experiments.....	.....	97	93	98	98	82
287 .....do.....	.....	96	90	97	97	78
289 .....do.....	.....	97	92	98	98	82
Average.....	.....	97	92	98	98	81

As regards protein and carbohydrates, the average digestibility was practically the same during the period when work was performed as when it was not. In the case of the fat, the average coefficient was slightly larger during the work period in each experiment. On the whole, the results indicate that meat, or a diet including a generous proportion of meat, was quite thoroughly assimilated by a subject performing a considerable amount of muscular work each day as well as when not working, and that the digestibility of the diet was not appreciably affected by the amount of muscular work performed. The latter deduction is in accord with those drawn by Wait<sup>a</sup> and by Atwater and Sherman,<sup>b</sup> from investigations on the effect of muscular work upon digestibility.

#### **DETAILS OF EXPERIMENTS WITH SIMPLE DIET, INCLUDING MEAT.**

Experiments such as those considered above show the digestibility of the total diet including meat, but they afford no indication of the digestibility of the meat itself. This may or may not be the same as that of the diet as a whole. It is very desirable, however, to know what proportion of the nutrients of meat will be digested when the meat is eaten in combination with other food materials. Particular attention was devoted to a study of this subject in connection with these investigations, and in all 44 experiments were made in which the digestibility of the meat was determined.

In 21 of these experiments the same kind and cut of meat—beef round—was cooked by different methods, namely, in water at 80° to 85° C. for one, two, and three hours, and by pan broiling, frying, and roasting; in 3 experiments beef shoulder was cooked in water for two hours; in 7 experiments beef ribs roasted were used; and in 13 experiments other kinds of meat, namely, veal, mutton, and pork, were cooked by roasting.

The subjects in these experiments were eight young men, designated as A, B, D, E, F, H, I, and J. Subjects A and B were chemists, who had served in the experiments reported in preceding pages. Subjects D, E, F, and H were university students, aged 20, 22, 24, and 21 years, respectively, who were employed more or less in the laboratory. Subject I was a high school pupil, 15 years old, who worked in the laboratory during spare hours. Subject J was a janitor, 25 years old. All of the subjects were in good health, and none of them found the exactations of the experiments in any way disagreeable. Subject B served in 18 experiments; he was in nearly every one of the different series, which were continued at intervals through four years. The experi-

<sup>a</sup> U. S. Dept. Agr., Office of Experiment Stations Bul. 89, p. 73.

<sup>b</sup> U. S. Dept. Agr., Office of Experiment Stations Bul. 98, p. 56.

ments with the other subjects were practically duplicates or triplicates of those with him. During this time his weight varied from 135 to 153 pounds, but in most of the experiments it was somewhere near 145 pounds. The weight of subject E varied from 118 to 125 pounds, and that of I from 132 to 142 pounds, in the experiments in which they served. Subject A weighed about 170 pounds, D about 152 pounds, F about 137 pounds, H about 140 pounds, and J about 130 pounds in each experiment in which they served.

Seven of the experiments continued two days, and all the others three days, as indicated later in the data of the experiments. In each case a very simple diet including the meat was eaten, as explained below, in order that the digestibility of the meat might be calculated.

*Experimental method.*—The digestibility of single food materials is sometimes studied by experiments in which the diet consists only of the material under consideration. There are several objections to such a method, however. In the first place, it is generally difficult to continue the experiment long enough to obtain satisfactory results because no matter how palatable the single food may be at first, to the ordinary individual accustomed to a mixed diet it commonly becomes distasteful, and sometimes the digestive functions are disturbed to such an extent that the results of the experiment are impaired. In the second place, even if the diet could be endured for a sufficient length of time, the digestibility as thus determined might differ from that of the same material when eaten in connection with other foods. As Prausnitz <sup>a</sup> has pointed out, there are three possibilities: (1) Each food may be digested as it would be if used alone; or (2) the digestibility of one may be increased, or (3) it may be diminished by the addition of the others. In digestion experiments made in this country it has been observed that the digestion of foods in a mixed diet is commonly more complete than that of any of the foods when eaten alone.

The question to be studied in these experiments with meat was, as suggested above, What proportion of each of the nutrients of meats of different kinds and cooked in different ways would be digested when the meat forms part of a diet of ordinary food materials? It was believed that a tolerably accurate answer to this question could be obtained from experiments with a very simple diet in which meat formed a considerable proportion of the total food eaten. Such a diet may be consumed with comfort for a sufficient length of time, even when the number of foods is small, and it has been found that in a diet of this character the nutrients are generally as thoroughly digested as in one composed of a larger number of food materials. Furthermore, the digestibility of the nutrients of a given material in the simple diet may be calculated when that of the foods with which

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<sup>a</sup> Arch. Hyg., 17 (1893), p. 626.

it is eaten is known or may be assumed. Woods<sup>a</sup> and Snyder<sup>b</sup> have in this way studied the digestibility of bread from the results of experiments with bread and milk. The ingredients of the feces that would be derived from the milk they calculated by use of previously determined factors for the digestibility of the milk, and assumed that the difference between these and the total ingredients of the feces would represent the ingredients due to the bread.

A similar method was followed by the authors of this report in the series of experiments with meat here considered. The diet consisted mainly of bread and meat, with milk or butter, or in some cases both, in addition. The subjects ate such quantities of any of these materials as they desired at each meal, though it was understood by all that the foods other than meat were eaten simply to keep the diet palatable and agreeable, and that the purpose was to have the meat form as large a proportion of the whole ration as was consistent with their comfort. The amounts of meat consumed by the same subject varied considerably in different experiments, principally because of differences in palatability due to different methods of preparation; but in all cases the quantity of meat eaten formed a relatively large proportion of the total diet. Since the materials other than meat were few in number, and were those the digestibility of which may be assumed with reasonable accuracy for the conditions of these experiments, it is possible to calculate quite satisfactorily the digestibility of the meat from the data obtained in the experiments.

The digestibility of the diet as a whole was found in the usual manner by subtracting from the amount of each nutrient of the total diet the amount of the corresponding ingredient in the total feces. In order to compute the digestibility of the protein and fat of the meat alone it was necessary to assume certain more or less arbitrary factors for the digestibility of the other foods eaten with the meat. For the purpose of these investigations it was assumed that 89 per cent of the protein and 90 per cent of the fat of the bread would be digested, these factors being based upon the results of digestion experiments with bread carried on by Woods and Snyder (above referred to) in connection with the nutrition investigations of the Department of Agriculture. In studying the digestibility of bread it was assumed that 98 per cent of the protein and 99 per cent of the fat of the milk and butter eaten with the bread would be digested, and these factors have also been applied to the same materials in the present experiments.

The method of estimating the digestibility of meat by the application of the above factors to the foods other than meat may be illustrated by data from experiment No. 293. In this case 0.8 gram of the total

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<sup>a</sup> U. S. Dept. Agr., Office of Experiment Stations Buls. 85, 143.

<sup>b</sup> U. S. Dept. Agr., Office of Experiment Stations Buls. 101, 126, 156.

protein of the diet was derived from butter, of which 99 per cent was assumed to be digested, thus leaving a negligible quantity in the feces; and 46.6 grams of protein were derived from bread, of which 89 per cent was assumed to be digested, leaving 5.1 grams in the feces. The total protein of the feces was 15 grams. Subtracting from this the sum of the amounts calculated as due to bread and milk, 5.1 grams, would leave 9.9 grams of the protein of the feces as due to meat. The total quantity of protein digested from the meat would then be  $168.3 - 9.9 = 158.4$  grams. Dividing this by the total in the meat consumed, 168.3 grams, and multiplying by 100, gives 94.1 per cent as the coefficient of digestibility of the meat protein. In like manner the digestibility of the fat of the meat was calculated.

#### EXPERIMENTS WITH LEAN BEEF COOKED IN WATER FOR ONE HOUR.

In the following 5 experiments the meat used consisted of lean beef round, which in each case was cooked in water at  $80^{\circ}$  to  $85^{\circ}$  C. for one hour.

Experiment No. 293 with subject A and No. 294 with subject B began with breakfast December 8, 1900, and continued two days (6 meals). The diet consisted of meat, bread, and butter. The cut of meat used in these experiments was from an animal about 4 years old.

Experiments Nos. 297, 300, and 301 with subjects D, E, and B, respectively, began with breakfast August 21, 1901, and continued three days (9 meals). The diet consisted of meat, bread, butter, and milk. The meat was from an animal about 3 years old.

The data of these experiments are given in Table 9.

TABLE 9.—*Results of digestion experiments with beef round cooked one hour in water at  $80$  to  $85^{\circ}$  C.*

Laboratory No.		Weight of material.	Total organic matter.	Protein ( $N \times 6.25$ ).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 293, subject A.</i>							
1131	Meat.....	640.0	193.3	168.3	25.0	.....	11.3
1132	Bread.....	600.0	327.9	46.6	2.3	279.1	4.1
1133	Butter.....	135.0	125.9	1.8	125.1	.....	1.5
1138	Total diet.....	1,375.0	647.1	215.7	152.4	279.1	15.9
	Total feces.....	38.8	30.9	15.0	3.4	12.5	4.1
	Estimated feces from meat.....	.....	.....	9.9	1.9	.....	.....
	Amount digested:						
	From total diet.....	616.2	200.7	149.0	206.6	11.8	
	From meat alone.....	.....	158.4	23.1	.....	.....	
	Per cent digested:						
	From total diet.....	95.2	93.0	97.8	95.5	74.2	
	From meat alone.....	.....	94.1	92.5	.....	.....	
<i>Experiment No. 294, subject B</i>							
1131	Meat.....	766.5	231.5	201.5	30.0	.....	13.5
1132	Bread.....	500.0	273.3	38.8	1.9	232.5	3.5
1133	Butter.....	95.0	88.6	1.6	88.0	.....	1.3
	Total diet.....	1,361.5	593.4	240.9	119.9	232.5	17.3

TABLE 9.—*Results of digestion experiments with beef round cooked one hour in water at 80 to 85° C.—Continued.*

Laboratory No.	Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 294, subject B—Con.</i>						
1139	Total feces.....	27.1	20.7	7.1	3.2	40.5
	Estimated feces from meat.....			3.8	2.1	.....
	Amount digested:					
	From total diet.....	572.6	233.8	116.7	222.1	12.7
	From meat alone.....		198.7	27.9	.....	.....
	Per cent digested:					
	From total diet.....	96.5	97.1	97.3	95.5	73.6
	From meat alone.....		98.6	93.1	.....	.....
<i>Experiment No. 291, subject D.</i>						
1244	Meat.....	1,000.0	297.6	274.2	23.4	.....
1233	Bread.....	100.0	53.7	7.2	7	45.8
1208	Butter.....	1.8	1.6	.....	1.6	.....
1234	Milk.....	3,073.2	358.6	97.1	120.8	140.7
	Total diet.....	4,175.0	711.5	378.5	146.5	186.5
1223	Total feces.....	21.5	14.7	5.9	2.6	6.1
	Estimated feces from meat.....			3.2	1.3	.....
	Amount digested:					
	From total diet.....	696.8	372.6	143.9	180.4	33.1
	From meat alone.....		271.0	22.1	.....	.....
	Per cent digested:					
	From total diet.....	97.9	98.4	98.2	96.7	86.8
	From meat alone.....		98.9	94.3	.....	.....
<i>Experiment No. 300, subject E.</i>						
1244	Meat.....	1,150.0	342.2	315.3	26.9	.....
1233	Bread.....	500.0	268.6	36.0	3.7	228.9
1234	Milk.....	4,021.5	469.3	127.1	158.0	184.2
	Total diet.....	5,671.5	1,080.1	478.4	188.6	413.1
1248	Total feces.....	55.6	28.9	15.7	9.5	3.7
	Estimated feces from meat.....			9.2	7.5	.....
	Amount digested:					
	From total diet.....	1,051.2	462.7	179.1	409.4	32.0
	From meat alone.....		306.2	19.4	.....	.....
	Per cent digested:					
	From total diet.....	96.5	96.7	94.5	99.1	64.3
	From meat alone.....		97.1	72.0	.....	.....
<i>Experiment No. 301, subject B.</i>						
1244	Meat.....	1,050.0	312.5	287.9	24.6	.....
1233	Bread.....	600.0	322.3	43.2	4.4	274.6
1208	Butter.....	50.0	44.2	3	43.8	.....
1234	Milk.....	2,353.2	274.6	74.4	92.5	107.8
	Total diet.....	4,054.2	953.6	405.8	165.3	382.4
1252	Total feces.....	37.6	24.2	11.2	4.0	8.9
	Estimated feces from meat.....			5.0	2.2	.....
	Amount digested:					
	From total diet.....	4,015.6	929.3	394.6	161.3	373.5
	From meat alone.....			283.0	22.4	.....
	Per cent digested:					
	From total diet.....	97.5	97.2	97.6	97.7	78.4
	From meat alone.....		98.3	91.0	.....	.....

## EXPERIMENTS WITH LEAN BEEF COOKED IN WATER FOR TWO HOURS.

In the five experiments following lean beef round cooked in water at 80 to 85° C., for two hours was used.

Experiment No. 290, with subject A, and No. 292, with subject B, began with breakfast November 21, 1900, and continued two days. The diet consisted of meat, bread, and butter. The cut of meat was from an animal about 6 years old.

Experiment No. 291, with subject B, began with breakfast November 9, 1900, and continued two days. The diet consisted of bread, milk, and meat. The meat was from an animal about 5 years old.

Experiment No. 298, with subject E, and 299, with subject B, began with breakfast August 7, 1901, and continued three days. The diet consisted of bread, butter, and milk in addition to the meat. The meat was from an animal about 3 years old.

The data of these experiments are given in Table 10.

TABLE 10.—*Results of digestion experiments with beef round cooked two hours in water at 80° to 85° C.*

Laboratory No.	Weight of material.	Total organic matter.	Protein (N × 6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 290, subject A.</i>						
1120 Meat.....	560.0	211.9	176.8	35.1	.....	10.2
1122 Bread.....	549.8	300.3	43.4	2.1	254.8	4.5
1123 Butter.....	160.0	148.0	1.3	146.7	.....	.9
1128 Total diet.....	1,269.8	650.2	221.5	183.9	254.8	15.6
Total feces.....	48.4	38.2	19.1	5.3	13.8	5.1
Estimated feces from meat.....	.....	.....	14.3	3.6	.....	.....
Amount digested:						
From total diet.....	622.0	202.4	178.6	241.0	.....	10.5
From meat alone.....	.....	162.5	31.5	.....	.....	.....
Per cent digested:						
From total diet.....	94.2	91.4	97.1	94.6	.....	67.5
From meat alone.....	.....	91.9	89.7	.....	.....	.....
<i>Experiment No. 291, subject B.</i>						
1108 Meat.....	497.5	178.6	150.0	28.6	.....	10.7
1116 Meat.....	235.9	89.0	79.4	9.6	.....	5.2
1109 Bread.....	500.0	265.4	37.4	1.8	226.2	6.7
1117 Milk.....	775.5	78.5	23.3	22.8	32.4	5.4
1115 Total diet.....	2,008.0	611.5	290.1	62.8	258.6	28.0
Total feces.....	38.3	20.0	10.7	4.7	14.6	5.7
Estimated feces from meat.....	.....	.....	6.1	4.3	13.9	.....
Amount digested:						
From total diet.....	581.5	279.4	58.1	244.0	.....	22.3
From meat alone.....	.....	223.3	33.9	.....	.....	.....
Per cent digested:						
From total diet.....	95.1	96.3	92.5	94.4	.....	79.7
From meat alone.....	.....	97.3	88.7	.....	.....	.....
<i>Experiment No. 292, subject C.</i>						
1120 Meat.....	780.0	295.2	246.3	48.9	.....	14.3
1122 Bread.....	500.0	273.1	30.5	1.9	231.7	4.1
1123 Butter.....	100.0	92.5	1.8	91.7	.....	.6
1129 Total diet.....	1,280.0	600.8	286.6	142.5	231.7	19.0
Total feces.....	24.0	18.3	8.2	3.3	6.8	3.7
Estimated feces from meat.....	.....	.....	3.9	2.2	.....	.....
Amount digested:						
From total diet.....	642.4	278.4	139.2	224.9	.....	15.2
From meat alone.....	.....	242.4	46.7	.....	.....	.....
Per cent digested:						
From total diet.....	97.2	97.2	97.7	97.1	.....	80.4
From meat alone.....	.....	98.5	95.5	.....	.....	.....
<i>Experiment No. 293, subject E.</i>						
1216 Meat.....	1,050.0	348.9	323.0	25.9	.....	17.0
1207 Bread.....	800.0	442.0	59.7	5.9	376.4	6.6
1208 Butter.....	50.0	44.2	1.3	43.8	.....	.1
1209 Milk.....	2,342.6	250.7	71.2	74.5	105.0	16.4
1232 do.....	2,873.7	310.7	81.3	96.8	132.5	19.0
1227 Total diet.....	7,116.3	1,396.5	535.5	246.9	613.9	59.1
Total feces.....	62.1	24.1	18.2	5.7	10.2	20.4
Estimated feces from meat.....	.....	.....	8.5	2.9	.....	.....
Amount digested:						
From total diet.....	1,362.4	517.3	241.2	603.7	.....	38.7
From meat alone.....	.....	314.4	23.0	.....	.....	.....
Per cent digested:						
From total diet.....	97.6	96.6	97.7	98.3	.....	65.5
From meat alone.....	.....	97.4	88.7	.....	.....	.....

TABLE 10.—*Results of digestion experiments with beef round cooked two hours in water at 80° to 85° C.*—Continued.

Laboratory No.	Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 299, subject B.</i>						
1216 Meat.....	900.0	299.1	276.8	22.2	.....	14.6
1207 Bread.....	400.0	331.5	44.8	4.4	282.3	5.0
1208 Butter.....	150.0	132.5	1.0	131.5	.....	.4
1209 Milk.....	2,105.3	225.3	64.0	66.9	94.3	14.7
1231 Total diet.....	3,755.3	988.4	286.6	225.0	376.6	34.7
Total feces.....	52.0	36.7	11.7	4.8	20.2	11.4
Estimated feces from meat.....	.....	.....	5.5	2.4	.....	.....
Amount digested:						
From total diet.....	951.7	374.9	220.2	356.4	.....	23.3
From meat alone.....	.....	271.4	19.9	.....	.....	.....
Per cent digested:						
From total diet.....	96.3	97.0	97.9	94.6	.....	67.1
From meat alone.....	.....	98.0	89.3	.....	.....	.....

## EXPERIMENTS WITH LEAN BEEF COOKED IN WATER FOR THREE HOURS.

Two experiments, No. 295 with subject A and No. 296 with subject B, were made with lean beef round, from an animal about 2 years old, cooked in water at 80° to 85° C. for three hours. They began with breakfast January 18, 1901, and continued two days.

The data of the experiments are given in Table 11.

TABLE 11.—*Results of digestion experiments with beef round cooked three hours in water at 80° to 85° C.*

Laboratory No.	Weight of material.	Total organic matter.	Protein (N×6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 295, Subject A.</i>						
1148 Meat.....	302.7	125.5	104.0	21.5	.....	5.2
1149 Bread.....	600.0	311.3	43.7	.9	266.7	5.3
1150 Butter.....	220.8	198.3	1.3	197.0	.....	1.6
1151 Milk.....	496.8	54.0	13.7	17.9	22.5	3.3
1156 Total diet.....	1,620.3	689.1	162.7	237.3	289.2	15.4
Total feces.....	18.0	14.3	5.1	2.2	7.0	2.5
Estimated feces from meat.....	.....	.....	3.3	1.1	.....	.....
Amount digested:						
From total diet.....	1,602.2	674.8	157.6	235.1	282.2	12.9
From meat alone.....	.....	.....	103.7	21.4	.....	.....
Per cent digested:						
From total diet.....	97.9	96.9	99.1	97.6	.....	83.8
From meat alone.....	.....	99.7	99.5	99.5	.....	.....
<i>Experiment No. 296, Subject B.</i>						
1148 Meat.....	400.0	165.8	137.4	28.4	.....	6.8
1149 Bread.....	488.3	253.4	35.5	.8	217.0	4.4
1150 Butter.....	80.0	71.9	.5	71.4	.....	.6
1151 Milk.....	1,135.5	123.4	31.2	40.9	51.3	7.6
1157 Total diet.....	2,103.8	614.5	204.6	141.5	268.3	19.4
Total feces.....	18.9	13.6	5.2	2.9	5.5	3.9
Estimated feces from meat.....	.....	.....	3.7	1.7	.....	.....
Amount digested:						
From total diet.....	2,084.9	600.9	199.4	138.6	262.8	15.5
From meat alone.....	.....	.....	136.7	267.3	.....	.....
Per cent digested:						
From total diet.....	97.8	97.5	97.9	97.9	.....	79.9
From meat alone.....	.....	99.5	94.0	94.0	.....	.....

## EXPERIMENTS WITH LEAN BEEF PAN BROILED.

The three following experiments were made with lean beef from an animal about 3 years old. The meat was cut into steaks about an inch thick, and pan broiled (fried without added fat) until well done. The cooked meat was then cut into strips, mixed with gravy obtained in cooking, seasoned to taste with salt and pepper, and then passed twice through a sausage mill. As thus prepared it was fairly well relished by each subject. All the subjects ate bread and milk in addition to the meat, and subject F used a little butter also.

Experiment No. 371, with subject F, and No. 372, with subject E, began with dinner March 18, 1901; and No. 373, with subject B, began with supper March 17. Each experiment continued three days (9 meals). The data of the experiments are given in Table 12.

TABLE 12.—*Results of digestion experiments with beef round pan broiled.*

Laboratory No.		Weight of material.	Total organic matter.	Protein (N × 6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 371, subject F.</i>							
1311	Milk.....	3,427.04	394.45	92.53	147.70	154.22	22.62
1312	Butter.....	50.00	44.45	.....	44.05	.....	1.18
1327	Bread.....	600.00	341.58	56.04	3.24	282.30	5.04
I313	Meat.....	1,100.00	447.70	313.06	134.64	.....	28.28
Total diet.....							
1318	Total feces.....	59.83	40.32	17.95	5.07	17.30	14.45
Estimated feces from meat.....							
Amount digested:							
From total diet.....							
From meat alone.....							
Per cent digested:							
From total diet.....							
From meat alone.....							
<i>Experiment No. 372, subject E.</i>							
1311	Milk.....	3,934.30	452.84	106.23	169.57	177.04	25.96
t327	Bread.....	700.00	398.51	65.38	3.78	329.35	5.88
1313	Meat.....	1,200.00	488.40	341.52	146.88	.....	30.96
Total diet.....							
1322	Total feces.....	40.52	23.51	14.16	3.59	5.76	11.86
Estimated feces from meat.....							
Amount digested:							
From total diet.....							
From meat alone.....							
Per cent digested:							
From total diet.....							
From meat alone.....							
<i>Experiment No. 373, subject B.</i>							
1311	Milk.....	2,640.58	304.63	71.46	114.07	119.10	17.46
1327	Bread.....	300.00	170.79	28.02	1.62	141.15	2.52
1313	Meat.....	1,200.00	488.40	341.52	146.88	.....	30.96
Total diet.....							
1326	Total feces.....	42.48	28.90	11.57	4.58	12.75	9.95
Estimated feces from meat.....							
Amount digested:							
From total diet.....							
From meat alone.....							
Per cent digested:							
From total diet.....							
From meat alone.....							

## EXPERIMENTS WITH LEAN BEEF FRIED.

The 3 following experiments, Nos. 374 to 376, with subjects F, E, and B, respectively, began with breakfast April 2, 1902, and continued three days (9 meals). The meat used was lean beef round from an animal about 3 years old. It was cut into steaks about half an inch thick, then fried in hot lard until well done. The cooked steaks were cut into strips, seasoned to taste with salt and pepper, and passed twice through a sausage mill. The meat was rather dry and not very well relished by the subjects. All the subjects ate bread and milk in addition to the meat, and subject F used some butter also. Table 13 contains the data of the experiments.

TABLE 13.—*Results of digestion experiments with beef round fried in hot lard.*

Laboratory No.		Weight of material.	Total organic matter.	Protein (N × 6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 374, subject F.</i>							
1329	Milk.....	3,805.00	445.56	108.82	161.71	175.03	31.58
1312	Butter.....	50.00	44.45	10.40	44.05	.....	1.18
1328	Bread.....	557.20	302.11	51.88	1.50	248.73	4.63
1330	Meat.....	800.00	361.52	271.76	89.76	.....	20.64
	Total diet.....	1,153.64	432.86	297.02	423.76	58.03	
1335	Total feces.....	54.26	35.45	15.46	3.76	16.23	14.06
	Estimated feces from meat.....			7.58	1.55	.....	
	Amount digested:						
	From total diet.....	1,118.19	417.40	293.26	407.53	43.97	
	From meat alone.....		264.18	88.21	.....	.....	
	Per cent digested:						
	From total diet.....	96.93	96.43	98.73	96.17	75.77	
	From meat alone.....		97.21	98.27	.....	.....	
<i>Experiment No. 375, subject E.</i>							
1329	Milk.....	3,651.22	427.56	104.42	155.18	167.96	30.30
1328	Bread.....	400.00	216.88	37.24	1.08	178.56	3.32
1330	Meat.....	900.00	406.71	305.73	100.98	.....	23.22
	Total diet.....	1,051.15	447.39	257.24	346.52	56.84	
1339	Total feces.....	65.63	37.73	19.95	5.93	11.85	20.12
	Estimated feces from meat.....			13.77	4.27	.....	
	Amount digested:						
	From total diet.....	1,013.42	427.44	251.31	334.67	36.72	
	From meat alone.....		291.96	96.71	.....	.....	
	Per cent digested:						
	From total diet.....	96.41	95.54	97.69	96.58	64.60	
	From meat alone.....		95.50	95.77	.....	.....	
<i>Experiment No. 376, subject B.</i>							
1329	Milk.....	4,237.39	496.20	121.19	180.09	194.92	35.17
1328	Bread.....	300.00	162.66	27.93	1.81	133.92	2.49
1330	Meat.....	700.00	316.33	237.79	78.54	.....	18.06
	Total diet.....	575.19	386.91	259.44	328.84	55.72	
1343	Total feces.....	42.21	27.60	8.87	2.77	15.96	11.12
	Estimated feces from meat.....			3.37	0.89	.....	
	Amount digested:						
	From total diet.....	947.59	378.04	256.67	312.88	44.60	
	From meat alone.....		234.42	77.65	.....	.....	
	Per cent digested:						
	From total diet.....	97.17	97.73	98.93	95.45	80.04	
	From meat alone.....		98.58	98.87	.....	.....	

## EXPERIMENTS WITH LEAN BEEF ROASTED.

Experiments Nos. 377-379, with subjects F, E, and B, respectively, began with breakfast April 16, 1903, and continued three days (9 meals). The meat used in these experiments was lean beef

round from an animal about 2 years old, roasted in an oven until well done. The cooked meat was cut into strips, mixed with gravy obtained in roasting, seasoned to taste with salt and pepper, and passed twice through a sausage mill. It had an excellent flavor and was relished by all the subjects. Table 14 gives the data of these experiments.

TABLE 14.—*Results of digestion experiments with beef round roasted.*

Laboratory No.		Weight of material.	Total organic matter.	Protein (N x 6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 377, subject F.</i>							
1346	Milk.....	3,950.19	478.36	114.15	164.33	199.88	29.63
1345	Butter.....	50.00	43.96	12.23	44.73	.....	1.20
1344	Bread.....	400.00	223.04	37.64	2.36	183.04	2.88
1347	Meat.....	1,200.00	456.84	357.24	99.60	.....	38.40
1352	Total diet.....	.....	1,203.20	509.26	311.02	382.92	72.11
	Total feces.....	35.01	22.83	9.97	2.02	10.84	8.73
	Estimated feces from meat.....	.....	.....	3.55	.....	.....	.....
	Amount digested:	.....	.....	.....	.....	.....	.....
	From total diet.....	.....	1,180.37	499.29	309.01	372.08	63.38
	From meat alone.....	.....	.....	353.69	99.60	.....	.....
	Per cent digested:	.....	.....	.....	.....	.....	.....
	From total diet.....	.....	98.10	98.04	99.33	97.17	87.89
	From meat alone.....	.....	.....	99.01	100.00	.....	.....
<i>Experiment No. 378, subject E.</i>							
1346	Milk.....	3,907.84	473.24	112.94	162.57	197.73	29.31
1344	Bread.....	300.00	167.28	28.23	1.77	137.28	2.16
1347	Meat.....	1,000.00	380.70	297.70	83.00	.....	32.00
1356	Total diet.....	.....	1,021.22	438.87	247.34	335.01	63.47
	Total feces.....	35.04	18.86	10.81	2.66	5.39	11.40
	Estimated feces from meat.....	.....	.....	5.45	.86	.....	.....
	Amount digested:	.....	.....	.....	.....	.....	.....
	From total diet.....	.....	1,002.36	428.06	244.68	329.62	52.07
	From meat alone.....	.....	.....	292.25	82.14	.....	.....
	Per cent digested:	.....	.....	.....	.....	.....	.....
	From total diet.....	.....	98.15	97.54	98.92	98.39	82.04
	From meat alone.....	.....	.....	98.17	98.96	.....	.....
<i>Experiment No. 379, subject B.</i>							
1346	Milk.....	3,407.87	412.69	98.49	141.76	172.44	25.56
1344	Bread.....	300.00	167.28	28.23	1.77	137.28	2.16
1347	Meat.....	1,200.00	456.84	357.24	99.60	.....	38.40
1360	Total diet.....	.....	1,036.81	483.96	243.13	309.72	66.12
	Total feces.....	27.78	18.05	6.32	1.74	9.99	7.33
	Estimated feces from meat.....	.....	.....	1.24	.15	.....	.....
	Amount digested:	.....	.....	.....	.....	.....	.....
	From total diet.....	.....	1,018.76	477.64	241.39	299.73	58.79
	From meat alone.....	.....	.....	356.00	99.45	.....	.....
	Per cent digested:	.....	.....	.....	.....	.....	.....
	From total diet.....	.....	98.24	98.69	99.28	96.77	88.91
	From meat alone.....	.....	.....	99.65	99.85	.....	.....

#### EXPERIMENTS WITH FAT BEEF COOKED IN WATER FOR TWO HOURS.

Experiments Nos. 368-370, with subjects F, E, and B, respectively, began with breakfast February 26, 1902, and continued three days (9 meals). The meat used in these experiments was fat beef shoulder, from an animal about 2½ years old, cooked in distilled water at 80° to 85° C. for two hours. The cooked meat was relished by all the subjects throughout the experiments. The diet included bread and milk in addition to the meat, and subject F used some butter also. The data of the experiments are tabulated in Table 15.

TABLE 45.—*Results of digestion experiments with fat beef shoulder cooked two hours in water at 80° to 85° C.*

Laboratory No.	Weight of material.	Total organic matter.	Protein (N × 6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 368, subject F.</i>						
1285 Milk.....	2,627.47	313.98	71.99	109.57	132.42	17.87
1286 Butter.....	50.00	45.26	1.30	44.96	.....	1.33
1281 Bread.....	600.00	329.28	51.66	5.28	272.34	5.28
1287 Meat.....	1,400.00	686.98	166.51	370.41	.....	22.40
Total diet.....	1,375.59	419.49	53.25	494.76	46.88	
1291 Total feces.....	75.76	54.48	18.67	10.01	25.50	14.70
Estimated feces from meat.....			11.55	7.91	.....	
Amount digested:						
From total diet.....	1,324.32	421.82	520.24	379.26	32.18	
From meat alone.....		334.99	362.50	.....	.....	
Per cent digested:						
From total diet.....	96.06	95.76	98.41	93.70	68.64	
From meat alone.....		96.35	97.86	.....	.....	
<i>Experiment No. 369, subject E.</i>						
1285 Milk.....	2,832.84	338.52	77.62	118.13	142.77	19.26
1301 do.....	793.61	79.35	18.09	22.14	39.43	5.32
1284 Bread.....	500.00	274.49	43.05	4.40	226.95	4.40
1287 Meat.....	1,400.00	686.98	166.51	370.41	.....	22.40
Total diet.....	1,379.26	455.39	515.41	408.85	51.38	
1295 Total feces.....	67.32	40.50	18.63	16.06	5.81	16.46
Estimated feces from meat.....			11.98	14.22	.....	
Amount digested:						
From total diet.....	1,338.76	436.67	499.05	403.04	34.92	
From meat alone.....		304.56	356.22	.....	.....	
Per cent digested:						
From total diet.....	97.06	95.91	96.88	98.58	67.96	
From meat alone.....		96.22	95.16	.....	.....	
<i>Experiment No. 370, subject B.</i>						
1285 Milk.....	1,035.10	123.69	28.36	43.16	52.17	7.04
1284 Bread.....	400.00	219.52	34.41	3.52	181.56	3.52
1287 Meat.....	1,500.00	736.05	339.15	396.90	.....	24.00
Total diet.....	1,079.26	401.95	443.58	233.73	34.56	
1299 Total feces.....	40.76	29.98	12.29	9.04	8.65	5.45
Estimated feces from meat.....			7.93	8.26	.....	
Amount digested:						
From total diet.....	1,049.28	389.66	431.54	225.08	29.41	
From meat alone.....		331.22	388.64	.....	.....	
Per cent digested:						
From total diet.....	97.22	96.91	97.97	96.30	85.10	
From meat alone.....		97.67	97.92	.....	.....	

## EXPERIMENTS WITH BEEF RIBS ROASTED.

In the following 7 experiments the cut of meat used was beef ribs, roasted in a gas oven until well done. The bones and surplus fat were removed from the roasted meat, and the remainder was used. The diet in each case included bread, butter, and milk in addition to the meat. Each experiment continued three days (9 meals).

Experiments Nos. 422 and 423, with subjects I and B, began with breakfast December 31, 1902. The meat used was from a 4-year-old Shorthorn cow in prime condition at the time of slaughter. Experiments Nos. 426 and 427, with subjects B and J, began with breakfast January 21, 1903. The meat used was from a 2-year-old Aberdeen-Angus cow, in rather thin condition at the time of slaughter. Experiment No. 428, with subject B, began with breakfast January 28, 1903.

The meat used was from a yearling Aberdeen-Angus steer in prime condition at the time of slaughter. Experiments Nos. 429 and 430, with subjects B and J, began with breakfast February 4, 1903. The meat used was from a well-fattened animal. Table 16 contains the data of these experiments.

TABLE 16.—*Results of digestion experiments with beef ribs roasted.*

Laboratory No.		Weight of material.	Total organic matter.	Protein (N × 6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 422, subject L.</i>							
1523	Milk.....	4,037.77	538.24	131.23	230.56	176.45	26.25
1524	Bread.....	800.00	444.48	69.44	3.20	371.84	6.46
1526	Butter.....	100.00	84.00	1.55	84.75	.....	2.77
1525	Meat.....	1,100.00	595.43	220.44	374.99	.....	21.23
1530	Total diet.....	1,603.05	421.66	603.10	548.29	56.81	
	Total feces.....	59.48	44.38	12.63	7.22	24.41	9.83
	Estimated feces from meat.....			2.37	3.85	.....	
	Amount digested:						
	From total diet.....	1,618.67	409.03	685.78	523.86	46.98	
	From meat alone.....		218.07	371.14	.....	.....	
	Per cent digested:						
	From total diet.....	97.32	97.00	98.94	95.54	82.70	
	From meat alone.....		98.92	98.97	.....	.....	
<i>Experiment No. 423, subject B.</i>							
1523	Milk.....	3,658.29	487.65	118.89	208.89	159.87	23.78
1524	Bread.....	800.00	444.48	69.44	3.20	371.84	6.96
1526	Butter.....	50.00	42.45	1.28	42.17	.....	1.18
1525	Meat.....	1,100.00	595.43	220.44	374.99	.....	21.23
1534	Total diet.....	1,570.01	409.05	629.25	521.71	59.15	
	Total feces.....	60.97	45.39	11.05	6.51	27.83	11.34
	Estimated feces from meat.....			1.03	3.68	.....	
	Amount digested:						
	From total diet.....	1,524.62	298.00	623.74	503.88	41.81	
	From meat alone.....		219.41	371.31	.....	.....	
	Per cent digested:						
	From total diet.....	97.11	97.70	99.12	94.77	78.66	
	From meat alone.....		99.53	99.02	.....	.....	
<i>Experiment No. 426, subject B.</i>							
1562	Milk.....	3,858.48	463.01	115.75	170.54	176.72	27.01
1563	Bread.....	700.00	392.07	64.82	2.52	324.73	5.04
1564	Butter.....	100.00	86.00	1.70	85.90	.....	2.38
1561	Meat.....	1,100.00	471.25	271.04	260.31	.....	28.05
1568	Total diet.....	1,413.03	452.31	459.27	501.45	62.48	
	Total feces.....	51.62	38.11	9.21	3.90	25.00	10.08
	Estimated feces from meat.....			2.08	1.08	.....	
	Amount digested:						
	From total diet.....	1,374.92	443.10	455.37	476.45	52.40	
	From meat alone.....		268.96	199.23	.....	.....	
	Per cent digested:						
	From total diet.....	97.20	97.96	99.15	95.02	83.87	
	From meat alone.....		99.23	99.46	.....	.....	
<i>Experiment No. 427, subject J.</i>							
1562	Milk.....	2,863.85	343.66	85.92	126.58	131.16	20.05
1563	Bread.....	800.00	418.08	74.08	2.88	371.12	5.76
1564	Butter.....	100.00	86.60	1.70	85.90	.....	2.38
1561	Meat.....	1,500.00	642.75	369.60	273.15	.....	38.25
1572	Total diet.....	1,521.09	531.30	188.51	502.28	66.41	
	Total feces.....	25.62	18.72	6.38	2.54	9.80	4.87
	Estimated feces from meat.....			1.13	.....	.....	
	Amount digested:						
	From total diet.....	1,502.37	523.92	485.97	492.48	61.57	
	From meat alone.....		369.60	273.02	.....	.....	
	Per cent digested:						
	From total diet.....	98.77	98.80	99.48	98.05	92.67	
	From meat alone.....		100.00	99.95	.....	.....	

TABLE 16. *Results of digestion experiments with beef ribs roasted—Continued.*

Lab- o- ra- to- ry No.		Weight of mate- rial.	Total organic matter.	Protein (N $\times$ 6.25).	Fat.	Carbohy- drates.	Ash.
<i>Experiment No. 428, subject B.</i>							
1597	Milk.....	2,426.80	292.43	73.29	100.95	118.49	16.02
1596	Bread.....	500.00	273.65	41.95	1.90	229.80	4.80
1598	Butter.....	100.00	89.00	1.67	88.33	.....	2.38
1595	Meat.....	1,100.00	534.82	226.16	308.66	.....	26.06
Total diet.....							
1602	Total feces.....	38.30	29.03	10.05	3.92	15.06	5.77
Estimated feces from meat.....							
Amount digested:							
From total diet.....							
From meat alone.....							
Per cent digested:							
From total diet.....							
From meat alone.....							
<i>Experiment No. 429, subject B.</i>							
1619	Milk.....	3,488.72	414.46	104.31	146.53	163.62	23.72
1618	Bread.....	700.00	400.49	60.20	5.53	334.46	5.88
1620	Butter.....	50.00	44.45	.41	44.04	.....	1.01
1617	Meat.....	1,103.00	597.30	259.93	337.37	.....	25.74
Total diet.....							
1621	Total feces.....	23.35	17.81	6.91	2.35	8.55	3.71
Estimated feces from meat.....							
Amount digested:							
From total diet.....							
From meat alone.....							
Per cent digested:							
From total diet.....							
From meat alone.....							
<i>Experiment No. 430, subject J.</i>							
1619	Milk.....	2,827.99	335.97	84.56	118.78	132.63	19.23
1618	Bread.....	800.00	457.36	68.80	6.32	382.24	6.72
1620	Butter.....	100.00	86.91	.82	86.09	.....	2.02
1617	Meat.....	1,600.00	868.80	378.08	490.72	.....	37.44
Total diet.....							
1628	Total feces.....	56.18	41.28	19.81	5.91	15.56	10.02
Estimated feces from meat.....							
Amount digested:							
From total diet.....							
From meat alone.....							
Per cent digested:							
From total diet.....							
From meat alone.....							

## EXPERIMENTS WITH FAT VEAL LEG ROASTED.

In these 6 experiments the meat used was very fat veal leg, roasted in a gas oven until well done, and seasoned to taste with salt and pepper. The cooked meat was relished by each subject throughout the experiments.

Each experiment continued three days (9 meals). All the subjects ate bread and milk in addition to the meat, and subjects I and B used butter also. Experiments Nos. 380, 382, and 383, with subjects H, I, and B, respectively, began with breakfast September 24, 1902. The meat used was from a calf about 10 weeks old. Experiments Nos. 419-421, with subjects H, I, and B, began with breakfast December 10, 1902. The data of these experiments are given in Table 17.

TABLE 17.—*Results of digestion experiments with veal roasted.*

Laboratory No.		Weight of material.	Total organic matter.	Protein (N × 6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 380, subject H.</i>							
1405	Milk.....	1,361.95	180.86	43.17	72.86	64.83	9.81
1429	do.....	1,800.43	216.55	56.56	71.81	88.18	12.47
1404	Bread.....	350.00	192.61	31.68	1.36	159.57	3.01
1406	Meat.....	1,300.00	580.84	365.56	215.28	.....	30.42
1411	Total diet.....	.....	1,470.86	496.97	361.31	312.58	55.71
	Total feces.....	45.56	32.36	18.41	4.01	9.94	7.91
	Estimated feces from meat.....	.....	.....	12.93	2.43	.....	.....
	Amount digested:						
	From total diet.....	.....	1,188.50	478.56	357.30	302.64	47.80
	From meat alone.....	.....	.....	352.63	212.85	.....	.....
	Per cent digested:						
	From total diet.....	.....	97.24	96.30	98.89	96.83	85.80
	From meat alone.....	.....	.....	96.46	98.87	.....	.....
<i>Experiment No. 382, subject I.</i>							
1405	Milk.....	1,352.67	179.64	42.88	72.37	64.39	9.74
1429	do.....	1,870.76	217.76	56.87	72.21	88.68	12.53
1404	Bread.....	900.00	495.27	81.45	3.51	410.31	7.74
1407	Butter.....	150.00	125.26	1.23	124.03	.....	4.32
1406	Meat.....	1,600.00	714.88	449.92	264.96	.....	37.44
1419	Total diet.....	.....	1,732.81	632.35	537.08	563.38	71.77
	Total feces.....	56.00	42.34	21.35	5.35	15.64	7.88
	Estimated feces from meat.....	.....	.....	10.38	2.31	.....	.....
	Amount digested:						
	From total diet.....	.....	1,690.47	611.00	531.73	547.74	63.89
	From meat alone.....	.....	.....	439.54	262.65	.....	.....
	Per cent digested:						
	From total diet.....	.....	97.55	96.62	99.00	97.22	89.02
	From meat alone.....	.....	.....	97.69	99.13	.....	.....
<i>Experiment No. 383, subject B.</i>							
1405	Milk.....	632.00	83.93	20.04	33.81	30.08	4.55
1429	do.....	1,301.58	151.50	39.57	50.24	61.69	8.72
1404	Bread.....	400.00	220.12	36.20	1.56	182.36	3.44
1407	Butter.....	50.00	41.76	.41	41.35	.....	1.44
1406	Meat.....	1,200.00	536.16	337.44	198.72	.....	28.08
1423	Total diet.....	.....	1,033.47	433.66	325.68	274.13	46.23
	Total feces.....	34.42	25.93	9.92	3.31	12.67	6.09
	Estimated feces from meat.....	.....	.....	4.74	1.93	.....	.....
	Amount digested:						
	From total diet.....	.....	1,007.54	423.74	322.34	261.46	40.14
	From meat alone.....	.....	.....	332.70	196.79	.....	.....
	Per cent digested:						
	From total diet.....	.....	97.49	97.71	98.97	95.38	86.83
	From meat alone.....	.....	.....	98.59	99.03	.....	.....
<i>Experiment No. 419, subject H.</i>							
1466	Milk.....	3,808.22	462.70	119.20	167.94	175.56	27.42
1467	Bread.....	600.00	321.72	48.06	2.40	271.26	4.92
1469	Meat.....	1,000.00	317.20	283.80	33.40	.....	24.70
1473	Total diet.....	.....	1,101.62	451.06	203.74	446.82	57.04
	Total feces.....	39.79	25.18	13.31	4.70	7.17	11.16
	Estimated feces from meat.....	.....	.....	5.64	2.78	.....	.....
	Amount digested:						
	From total diet.....	.....	1,076.44	437.75	199.04	439.65	45.88
	From meat alone.....	.....	.....	278.16	30.62	.....	.....
	Per cent digested:						
	From total diet.....	.....	97.71	97.05	97.69	98.40	80.43
	From meat alone.....	.....	.....	98.01	91.67	.....	.....
<i>Experiment No. 420, subject I.</i>							
1466	Milk.....	3,994.34	485.31	125.02	176.45	184.14	28.76
1467	Bread.....	700.00	375.31	56.07	2.80	316.47	5.74
1468	Butter.....	150.00	132.83	.83	132.00	.....	2.43
1469	Meat.....	1,100.00	348.92	312.18	36.74	.....	27.17
1477	Total diet.....	.....	1,342.40	494.10	347.69	500.61	64.10
	Total feces.....	25.73	19.29	6.41	2.99	9.89	4.55
	Estimated feces from meat.....	.....	.....	2.24	.....	.....	.....
	Amount digested:						
	From total diet.....	.....	1,323.11	487.69	344.70	490.72	59.55
	From meat alone.....	.....	.....	311.94	36.74	.....	.....
	Per cent digested:						
	From total diet.....	.....	98.57	98.70	99.14	98.02	92.90
	From meat alone.....	.....	.....	99.92	100.00	.....	.....

TABLE 17.—*Results of digestion experiments with veal roasted—Continued.*

Laboratory No.	Weight of material.	Total organic matter.	Protein (N × 6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 371, subject B.</i>						
1466 Milk.....	2,574.66	312.82	80.59	113.54	118.09	18.54
1467 Bread.....	700.00	375.34	56.07	2.80	316.47	5.74
1468 Butter.....	100.00	88.55	1.55	88.00	.....	1.62
1469 Meat.....	1,000.00	317.20	283.80	33.40	.....	24.70
Total diet.....		1,093.91	421.01	237.74	435.16	50.60
1481 Total feces.....	26.87	19.69	5.90	2.78	11.01	5.43
Estimated feces from meat.....				.48	.....	.....
Amount digested:						
From total diet.....		1,074.22	415.11	234.96	424.15	45.17
From meat alone.....			283.80	32.92	.....	.....
Per cent digested:						
From total diet.....		98.20	98.60	98.83	97.47	89.27
From meat alone.....			100.00	98.56	.....	.....

## EXPERIMENTS WITH MUTTON LEG ROASTED.

Experiments Nos. 381, 384, and 385, with subjects H, I, and B, respectively, began with breakfast October 8, 1902, and continued three days. All the subjects ate bread, milk, and meat, and subjects I and B added butter. The meat was very fat leg of mutton, from an animal about 1 year old, roasted in a gas oven until well done, and was well relished by each subject. Subject H felt somewhat indisposed toward the close of the experiment. The data of the experiments are given in Table 18.

TABLE 18.—*Results of digestion experiments with mutton roasted.*

Laboratory No.	Weight of material.	Total organic matter.	Protein (N × 6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 381, subject H.</i>						
1435 Milk.....	3,166.11	362.84	103.22	116.83	142.79	23.11
1437 Bread.....	500.00	275.80	45.40	2.05	228.35	3.85
1438 Meat.....	1,000.00	469.20	251.00	218.20	.....	28.90
1447 do.....	200.00	93.24	59.14	34.10	.....	4.90
Total diet.....		1,201.08	458.76	371.18	371.14	60.76
1415 Total feces.....	73.85	53.02	23.65	6.45	22.92	11.30
Estimated feces from meat.....			16.59	5.80	.....	.....
Amount digested:						
From total diet.....		1,148.06	435.11	364.73	348.22	49.46
From meat alone.....			293.55	247.22	.....	.....
Per cent digested:						
From total diet.....		95.59	94.85	98.26	93.82	81.40
From meat alone.....			94.65	97.99	.....	.....
<i>Experiment No. 384, subject I.</i>						
1435 Milk.....	3,382.21	387.60	110.26	124.80	152.54	62.69
1437 Bread.....	850.00	468.86	77.18	3.49	388.19	4.55
1436 Butter.....	150.00	126.02	1.19	124.83	.....	4.77
1438 Meat.....	1,200.00	563.04	301.20	261.84	.....	34.68
1447 do.....	300.00	139.86	88.71	51.15	.....	7.35
Total diet.....		1,685.38	578.54	566.11	540.73	78.04
1442 Total feces.....	72.12	52.27	22.05	6.84	23.38	10.26
Estimated feces from meat.....			11.34	3.99	.....	.....
Amount digested:						
From total diet.....		1,633.11	556.49	559.27	517.35	67.78
From meat alone.....			378.57	309.00	.....	.....
Per cent digested:						
From total diet.....		96.90	96.19	98.79	95.68	86.87
From meat alone.....			97.09	98.73	.....	.....

TABLE 18.—*Results of digestion experiments with mutton roasted—Continued.*

Laboratory No.		Weight of material.	Total organic matter.	Protein (N × 6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 385, subject E.</i>							
1435	Milk.....	3,475.27	398.26	113.29	128.24	156.73	25.37
1437	Bread.....	750.00	413.71	68.10	3.08	342.53	5.77
1436	Butter.....	100.00	84.01	.79	83.22	.....	3.18
1438	Meat.....	800.00	375.36	200.80	174.56	.....	23.12
1447	do.....	400.00	186.48	118.28	68.20	.....	9.80
1446	Total diet.....	.....	1,457.82	501.26	457.30	499.26	67.24
	Total feces.....	53.29	41.04	11.36	5.29	24.39	9.78
	Estimated feces from meat.....	.....	.....	1.60	2.87	.....	.....
	Amount digested:						
	From total diet.....	.....	1,416.78	489.90	452.01	474.87	57.46
	From meat alone.....	.....	.....	317.48	239.89	.....	.....
	Per cent digested:						
	From total diet.....	.....	97.17	97.73	98.84	95.11	85.45
	From meat alone.....	.....	.....	99.50	98.82	.....	.....

## EXPERIMENTS WITH PORK ROASTED.

Four experiments, each of three days' (9 meals) duration, were made with very fat fresh pork (ham), roasted in a gas oven until well done, and seasoned to taste with salt and pepper. The meat was relished in all the experiments. In each case bread, butter, and milk were eaten in addition to the meat.

Experiment No. 386 with subject I, and No. 387 with subject B, began with breakfast October 22, 1902. In these experiments most of the visible fat was removed from the meat before it was cooked. Experiments Nos. 424 and 425, with subjects I and J, began with breakfast January 13, 1903. The ham used in these experiments was from a Duroe-Jersey hog about 8 months old, fattened for market on a ration consisting of peas, oats, and barley. The entire ham with the bone, but with only a part of the skin, was roasted in a gas oven until well done. The bone and skin were then removed. Table 19 gives the data of these experiments.

TABLE 19.—*Results of digestion experiments with pork roasted.*

Laboratory No.		Weight of material.	Total organic matter.	Protein (N × 6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 387, subject I.</i>							
1449	Milk.....	4,725.38	543.42	150.27	180.98	212.17	39.22
1450	Bread.....	700.00	393.47	64.05	2.17	327.25	4.07
1451	Butter.....	150.00	129.26	.83	128.43	.....	3.16
1452	Meat.....	1,100.00	570.46	350.02	220.44	.....	24.86
1456	Total diet.....	.....	1,636.61	565.17	532.02	539.42	72.21
	Total feces.....	39.69	28.47	12.79	4.39	11.29	8.06
	Estimated feces from meat.....	.....	.....	2.73	1.08	.....	.....
	Amount digested:						
	From total diet.....	.....	1,608.14	552.38	527.63	528.13	64.15
	From meat alone.....	.....	.....	347.29	219.36	.....	.....
	Per cent digested:						
	From total diet.....	.....	98.25	97.74	99.47	97.91	88.84
	From meat alone.....	.....	.....	99.22	99.51	.....	.....

TABLE 19. *Results of digestion experiments with pork roasted—Continued.*

Laboratory No.		Weight of material.	Total organic matter.	Protein (N × 6.25).	Fat.	Carbohydrates.	Ash.
<i>Experiment No. 382, subject B.</i>							
1449	Milk.....	3,786.51	435.44	120.41	145.02	170.01	31.43
1450	Bread.....	600.00	337.26	54.90	1.86	280.50	4.26
1451	Butter.....	100.00	86.17	.55	85.62	.....	2.11
1452	Meat.....	1,000.00	518.60	318.20	200.40	.....	22.60
1460	Total diet.....		1,377.47	494.06	432.90	450.51	60.40
	Total feces.....	44.73	32.91	10.65	3.74	18.52	9.11
	Estimated feces from meat.....			2.20	1.25	.....	
	Amount digested:						
	From total diet.....		1,344.56	483.41	429.16	431.99	51.29
	From meat alone.....			316.00	199.15	.....	
	Percent digested:						
	From total diet.....		97.61	97.84	99.11	95.89	84.92
	From meat alone.....			99.31	99.38	.....	
<i>Experiment No. 424, subject I.</i>							
1547	Milk.....	3,006.87	343.99	97.12	116.37	130.50	21.65
1548	Bread.....	500.00	276.15	41.95	1.15	233.05	4.00
1549	Butter.....	100.00	88.80	1.00	87.80	.....	1.09
1546	Meat.....	1,000.00	453.70	251.30	202.40	.....	23.70
1553	Total diet.....		1,162.64	391.37	407.72	363.55	50.44
	Total feces.....	28.70	20.91	8.60	3.09	9.22	5.31
	Estimated feces from meat.....			2.04	.98	.....	
	Amount digested:						
	From total diet.....		1,141.73	382.77	404.63	354.33	45.13
	From meat alone.....			249.26	201.42	.....	
	Percent digested:						
	From total diet.....		98.20	97.80	99.24	97.46	89.47
	From meat alone.....			99.19	99.52	.....	
<i>Experiment No. 425, subject J.</i>							
1547	Milk.....	3,166.11	362.20	102.26	122.53	137.41	22.80
1548	Bread.....	800.00	441.84	67.12	1.84	372.88	6.40
1549	Butter.....	150.00	133.20	1.50	131.70	.....	1.64
1560	Meat.....	1,000.00	423.70	261.00	162.70	.....	32.30
1557	Total diet.....		1,360.94	431.88	418.77	510.29	63.14
	Total feces.....	43.25	30.52	13.40	4.05	13.07	9.37
	Estimated feces from meat.....			3.97	1.32	.....	
	Amount digested:						
	From total diet.....		1,330.42	418.48	414.72	497.22	53.77
	From meat alone.....			257.03	161.38	.....	
	Percent digested:						
	From total diet.....		97.76	96.90	99.03	97.44	85.16
	From meat alone.....			98.49	99.19	.....	

**SUMMARY AND DISCUSSION OF RESULTS.**

In Table 20 are summarized the results of the 44 digestion experiments with a simple diet in which the amount of meat formed a large proportion of the total food eaten. The figures here given are the proportions of the different nutrients that were digested, that is, the coefficients of digestibility.

TABLE 20.—*Coefficients of digestibility of nutrients of different meats in experiments Nos. 290–301, 368–387, 419–430.*

Experiment No.	Subject.	Kind of meat and method of cooking.	Total diet.				Meat alone.	
			Protein.	Fats.	Carbohydrates.	Ash.	Protein.	Fat.
293	A	Lean beef round, cooked in water at 80–85° C. for 1 hour.....	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
			93.0	97.8	95.5	74.2	94.1	92.5
294	B	do .....	97.1	97.3	95.5	73.6	98.6	93.1
297	D	do .....	98.4	98.2	96.7	86.8	98.9	94.3
300	E	do .....	96.7	94.5	99.1	64.3	97.1	<sup>a</sup> 72.0
301	B	do .....	97.2	97.6	97.7	78.4	98.3	91.0
		Average.....	96.5	97.1	96.9	76.5	97.3	92.6
290	A	Lean beef round, cooked in water at 80–85° C. for 2 hours.....	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
			91.4	97.1	94.6	67.5	91.9	89.7
291	B	do .....	96.3	92.5	94.4	79.7	97.3	88.7
292	B	do .....	97.2	97.7	97.1	80.6	98.4	95.5
298	E	do .....	96.6	97.7	98.3	65.5	97.4	88.7
299	B	do .....	97.0	97.9	94.6	67.1	98.0	89.3
		Average.....	95.7	96.6	95.8	72.0	96.6	90.4
295	A	Lean beef round, cooked in water at 80–85° C. for 3 hours.....	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
			96.9	99.1	97.6	83.8	99.7	99.5
296	B	do .....	97.5	97.9	97.9	79.9	99.6	93.6
		Average.....	97.2	98.5	97.7	81.8	99.7	96.6
371	F	Lean beef round, pan broiled.....	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
			96.1	98.5	96.0	74.8	96.8	97.9
372	E	do .....	97.2	98.9	98.9	81.1	98.6	99.0
373	B	do .....	97.4	98.3	95.1	80.5	97.9	97.8
		Average.....	96.9	98.5	96.7	78.8	97.8	98.2
374	F	Lean beef round, fried in hot lard.....	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
			96.4	98.7	96.2	75.8	97.2	98.3
375	E	do .....	95.5	97.7	96.6	64.6	95.5	95.8
376	B	do .....	97.7	98.9	95.2	80.0	98.6	98.9
		Average.....	96.6	98.5	96.0	73.5	97.1	97.7
377	F	Lean beef round, roasted.....	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
			98.0	99.3	97.2	87.9	99.0	100.0
378	E	do .....	97.5	98.9	98.4	82.0	98.2	99.0
379	B	do .....	98.7	99.3	96.8	88.9	99.7	99.9
		Average.....	98.1	99.2	97.4	86.3	98.9	99.7
388	F	Fat beef shoulder, cooked in water at 80–85° C. for 2 hours.....	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
			95.8	98.1	93.7	68.6	96.4	97.9
379	E	do .....	95.9	96.9	98.6	68.0	96.2	96.2
370	B	do .....	96.9	98.0	96.3	85.1	97.7	97.9
		Average.....	96.2	97.7	96.2	73.9	96.8	97.3
422	I	Beef ribs, roasted.....	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
			97.0	98.9	95.5	82.7	98.9	99.0
423	B	do .....	97.3	99.1	94.8	78.7	99.5	99.0
426	B	do .....	98.0	99.2	95.0	83.9	99.2	99.5
427	J	do .....	98.8	99.5	98.1	92.7	100.0	99.9
428	B	do .....	97.1	99.2	95.7	88.3	98.3	99.4
429	B	do .....	98.4	99.6	98.3	93.4	99.9	100.0
430	J	do .....	95.3	99.2	97.0	84.7	97.2	99.3
		Average.....	97.5	99.2	96.2	86.3	99.0	99.4
380	H	Veal leg, roasted.....	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
			96.3	98.9	95.8	85.8	96.5	98.9
382	I	do .....	96.6	99.9	97.2	89.0	97.7	99.1
383	B	do .....	97.7	99.9	95.4	86.8	98.6	99.0
419	II	do .....	97.1	97.7	98.4	80.4	98.0	91.7
420	I	do .....	98.7	99.1	98.0	92.9	99.8	100.0
421	B	do .....	98.6	98.8	97.5	89.3	100.0	98.6
		Average.....	97.5	98.8	97.2	87.4	98.4	97.9
381	H	Mutton leg, roasted.....	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
			94.9	98.3	93.8	81.4	94.7	98.0
384	I	do .....	96.2	98.8	95.7	86.9	97.1	98.7
385	B	do .....	97.7	98.8	95.1	85.5	99.5	98.8
		Average.....	96.3	98.6	94.9	84.6	97.1	98.5
386	I	Pork (fresh ham), roasted.....	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
			97.7	99.2	97.9	88.8	99.2	99.5
387	B	do .....	97.8	99.1	95.9	84.9	99.3	99.4
424	I	do .....	97.8	99.2	97.5	89.5	99.2	99.5
425	J	do .....	96.9	99.0	97.4	85.2	98.5	99.2
		Average.....	97.6	99.1	97.2	87.1	99.1	99.4
		Average for all experiments.....	96.9	98.3	96.6	80.7	98.0	97.1

<sup>a</sup> Not included in the average.

*Digestibility of total diet.*—One part of Table 20 shows the coefficients of digestibility of the nutrients of the total diet. In the average of the 44 experiments 97 per cent of the total quantity of protein eaten, 98 per cent of the total fat, and 97 per cent of the total carbohydrates were digested. If the 23 experiments with more varied diet, including meat, given on pages 13 to 23, are averaged, the coefficients for fat and carbohydrates are identical with these just given, but that for protein is 93 per cent. The reason for this lower figure for protein in the more varied diets is that the latter contains relatively large proportions of vegetable foods, in which the protein is not so thoroughly digested as in meat, which formed so much larger proportion of the total food in the more simple diets. In the average of upward of 400 experiments with various kinds of mixed diets made in connection with the nutrition investigations of this Department the coefficients of digestibility of the nutrients were found to be protein 92, fat 95, and carbohydrates 97 per cent. It is apparent, therefore, that the nutrients in the simple diet used in the experiments here summarized were thoroughly digested.

The minor averages in Table 20, i. e., the averages of the results of similar experiments, agree favorably with the general average. Thus the coefficients for protein range in the various averages from 96 to 98 per cent, those for fat from 97 to 99 per cent, and those for carbohydrates from 95 to 98 per cent. It is also noticeable that the results for different subjects in similar experiments agree, in almost every case, about as closely as can be expected in investigations of this nature. There are, in fact, only three noteworthy exceptions. In the experiments with lean beef cooked in water one hour, one subject digested 93 per cent of the protein, whereas the other four subjects digested 97 to 98 per cent. In the experiments with lean beef cooked in water two hours, one subject digested 91 per cent of the protein as compared with 96 to 97 for the other four subjects, and one subject digested 93 per cent of the fat, whereas each of the other four subjects digested 97 per cent. In all of the other experiments the agreement in results for all the different subjects on the same diet was satisfactorily close.

It would appear from these data that differences in the method of cooking the meat had little influence upon the digestibility of the nutrients of the total diet. For example, lean beef round was cooked in six different ways, and in these experiments the coefficients for protein in the total diet range, in the averages, from 96 to 98 per cent, those for fat from 97 to 99 per cent, and those for carbohydrates from 96 to 98 per cent.

It is also noticeable that there is not any practical difference in digestibility of the diets with different kinds of meat similarly cooked. Thus the average for the total diet in experiments with fat beef

shoulder cooked in water agrees closely with that for lean beef round similarly cooked; and in the experiments with lean beef round, beef ribs, veal, mutton, and pork, all roasted, the average coefficients range for protein from 95 to 97 per cent. These variations are smaller than some of those between the results for different individuals with the same kind of meat.

In brief, then, whether individual experiments or average figures be considered, differences in either the kind of meat or in the method of cooking the meat apparently had no decided effect upon the digestibility of the nutrients of the total diet used in these experiments.

*Digestibility of the meat alone.*—The data in the last two columns of Table 20 show the coefficients of digestibility of the protein and the fat of the meat alone as distinguished from those for the corresponding nutrients in the total diet. These values were computed, in the manner described on page 26, from the data for total diet as directly determined by the experiments, by assuming certain factors for the digestibility of the nutrients of the foods eaten with meat. These factors are based upon the results of digestion experiments with such food materials. It is, of course, not impossible that some error is involved in their use in the present experiments, but whatever error there may be is believed to be small, and the computed coefficients of digestibility of the protein and fat of the meat alone are believed to be approximately correct. At any rate, since the same factors are applied to all experiments alike, the results computed by use of them are just as comparable with each other as those determined for the total diet directly from the experimental data. It is possible, therefore, to judge from the figures in the table what was the effect of the different methods of cooking upon the digestibility of the nutrients of the meat alone.

As regards protein, no effect seems to be indicated. The range in coefficients for the minor averages is from 97 to 100 per cent, and the average for all 44 experiments is 98 per cent. The agreement between results for individual subjects in similar experiments was correspondingly close in nearly every case, the chief exception being the results with subject A in the experiments with lean beef cooked in water for one and for two hours; but in both of these sets of experiments the results with the other subjects agree closely with each other.

Considering all the figures, both those for different subjects in similar experiments and the averages for the different kinds of experiments, the indications are that the protein of the meat was quite thoroughly digested, whether the same kind of meat was cooked in different ways or different kinds of meat were similarly cooked. The variations for the different experiments are too small and too irregular to indicate any effect upon digestibility that may be ascribed to differences in the kinds of meat used or in the methods of cooking.

The same is true as regards fat, except in the case of lean beef cooked

in water. If these experiments be disregarded, the computed coefficients for fat agree very favorably with each other in the minor averages, the range being also from 97 to 100 per cent, and the general average for these 32 experiments being 99 per cent. The results with the different subjects in similar experiments also agree closely with each other with one exception—the coefficient for one subject with roast veal being 92 per cent, whereas those for the other five subjects ranged from 99 to 100 per cent.

In the experiments with lean beef cooked in water, the calculated coefficients for fat are decidedly low, both in the case of meat cooked for one hour and in that of meat cooked for two hours. The average for the meat cooked for three hours is better, but there were only two of these experiments, in one of which the coefficient is high, and this raised the average figure. In the other of these two experiments, the coefficient is like those for meat cooked one hour.

These low figures would at first appear to indicate that the fat of meat cooked in water was less thoroughly digested than that of meat otherwise cooked, but it is believed that such conclusions should not be drawn from these data. The low coefficients are more probably to be ascribed to slight inaccuracy in the assumed factors for digestibility of the fat of the foods other than meat. The quantity of fat in the meat in these particular experiments forms only a small proportion of the total fat of the diet, and where such is the case slight variations in the assumed factor for the fat of the other foods make relatively large differences in the computed coefficients for the fat of the meat. It is very probable that if the proportion of fat in the meat used in these 12 experiments had been larger the coefficients would have been more like those for the meat used in the other experiments. This is indicated by the fact that in the 3 experiments with fat beef shoulder cooked in water two hours, in which the meat supplied a larger part of the fat of the diet, the coefficients for fat agree with those for meat otherwise cooked, and also by the fact that the fat of the total diet—that is, fat from all the food materials including the meat—was as thoroughly digested in these experiments as in the others. There seems, therefore, no reason for believing that the fat of the meat alone was any less thoroughly digested in these than in the other experiments.

Considering all the experiments, it seems fair to assume from the data here summarized that about 98 per cent of the protein and 98 per cent of the fat of the meat were digested, and inasmuch as the simple diet used in these experiments was, as a whole, at least as thoroughly digested as the ordinary mixed diet, these data may be considered as representing the digestibility of the nutrients of meat eaten in combination with other common food materials.

Poda and Prausnitz<sup>a</sup> studied the digestibility of roasted beef in a comparatively simple diet, and by making allowance for the digestibility of the additional food materials in the diet as previously estimated, they computed the digestibility of the meat itself. They found that 99 per cent of the protein of the meat was digested, which agrees with the figure given above for the average of the experiments here reported. Other investigators have reported experiments in which the diet included meat together with other food materials—for example, bread, which was the special object of study—and it would apparently be possible from the results of these to estimate the digestibility of the meat alone. A cursory examination of the results of some of these experiments indicates that the estimated digestibility of the meat would correspond with that obtained in the experiments here considered. But inasmuch as such estimates were not previously reported by the investigators themselves, the work has not been summarized in the present publication for comparison.

The investigation by Forster, mentioned on page 6, is of interest here, as the object was, like that of the experiments reported in the present bulletin, to determine the digestibility of meat cooked in different ways. He made 33 experiments in 7 series, in which different cuts of beef were prepared as follows: (1) Raw, chopped, and flavored with salt, pepper, and onion; (2) cooked in butter, i. e., cut in slices 1 to 1.5 centimeters thick, sprinkled with salt and pepper, pounded, and fried for three to five minutes in a pan containing sufficient melted butter to cover the meat. Meat thus prepared was considered the most palatable of any used; (3) cut as in 2, and broiled (or roasted) for four minutes, with frequent turning in a closed, gas-heated grilling apparatus; (4) placed with flavoring matters in cold water and boiled for one and one-half to two hours; (5) same as 4, save that the water at the start was at the boiling point; (6) soaked for two weeks in brine, removed twenty-four hours before use, soaked in water, and boiled; (7) salted as in 6, then smoked for three days, soaked in water, and boiled. In four series of experiments two cuts from the same animal were used, a cheaper one from the hind shank and a more expensive one from the shoulder. For the roasted meat only that from the shank was used, and for the salted and smoked meats only the shoulder.

The solid food consisted entirely of the meat, but beer or wine, to which all the subjects were accustomed, was allowed at meals. Two or more subjects were employed in each series, the author himself serving in all of them. The food and fees were weighed and analyzed in the usual manner. The results obtained in these experiments are summarized by averages in Table 21.

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<sup>a</sup> Ztschr. Biol., 42 (1901), p. 377.

TABLE 21.—*Results of digestion experiments with meat alone.*

Kind of meat.	Coefficients of di-gestibility.		Kind of meat.	Coefficients of di-gestibility.	
	Protein.	Fat.		Protein.	Fat.
Hind quarter, raw, average of 5 experiments.....	Per cent. 95.23	Per cent. 83.58	Shoulder, boiled, average of 4 experiments.....	Per cent. 96.40	Per cent. 81.09
Shoulder, raw, average of 7 experiments.....	96.70	87.33	Hind quarter, boiled, average of 3 experiments.....	96.54	51.82
Hind quarter, fried in butter, average of 2 experiments....	96.32	95.19	Shoulder, pickled, average of 3 experiments.....	96.81	94.82
Shoulder, fried in butter, average of 2 experiments.....	97.71	98.62	Shoulder, salted and smoked, average of 3 experiments...	97.35	86.82
Hind quarter, broiled, average of 4 experiments.....	95.46	88.70			

In these experiments the digestibility of the protein of the meat was in all cases quite thorough, and the results for the different subjects agree fairly well with each other. The averages for the experiments with meat cooked in different ways range from 95 per cent with broiled meat to 98 per cent with meat fried in butter. In the average of all 33 experiments the digestibility of the protein was 96 per cent. This is a trifle lower than the average for the digestibility of protein of meat alone in Table 21 above, but the difference is insignificant. The lower average in Forster's experiments is possibly due partly to the fact that meat formed the total food material, whereas in the experiments here reported meat was eaten in combination with other common food materials. It has been commonly observed, as already explained, that a given food material may be more thoroughly digested when it is eaten with other food materials than when eaten alone. In view of this fact the figure for digestibility of protein obtained in the experiments here reported is believed to be supported by the results obtained by Forster in experiments such as his. Furthermore, the agreement in the results with meat cooked in different ways shows that the differences in the method of cooking had no effect upon the digestibility of the protein of the meat, which also supports the deduction drawn from the experiments reported in the present bulletin.

As regards the digestibility of fat, most of the results obtained by Forster were noticeably lower than those found in the present experiments. In 3 cases among the average figures given in the table above the digestibility of fat ranged from 95 to 99 per cent, but in 5 cases the coefficients ranged from 81 to 89 per cent; and in 1 case it is as low as 52 per cent. These variations are so wide that the results are hardly to be considered in drawing deductions regarding the digestibility of the fat of meat cooked in different ways.

**DIGESTIBILITY OF THE NITROGEN (PROTEIN) AS CORRECTED  
FOR METABOLIC PRODUCTS IN THE FECES.**

The values for digestibility considered in the preceding discussion are those determined according to the usual custom, by analyzing the food and the corresponding feces in the same manner and deducting the ingredients of the latter from those of the former. It is understood that this represents apparent rather than actual digestibility, because, as has been frequently pointed out, the feces do not consist entirely of undigested food. In fact they are composed in large part of the so-called metabolic products, which consist of residues from the digestive juices, epithelial débris from the mucous lining of the intestines, etc. Some of these products contain nitrogen, which is of course included with that from the undigested food in the total nitrogen of the feces as ordinarily determined; and they also contain substances that are soluble in ether and are extracted along with the undigested fat. To determine the actual digestibility of food it would therefore be necessary to separate the ingredients of the metabolic products from those of the undigested food.

Various methods for making such separation, and thus affording means for determining the ingredients of undigested food, have been tried by different investigators, but no attempt has been made to summarize them here. It will suffice to say that none of the methods thus far proposed has proved entirely satisfactory. In connection with the digestion experiments with meat in a very simple diet reported in this bulletin, however, an effort was made to get some light upon the actual digestibility of the protein of the meat by following one of the common methods of removing metabolic nitrogen from the feces. This consists of digesting the feces with an acid-pepsin solution, on the assumption that this will dissolve the metabolic products containing nitrogen but will not affect to any appreciable extent the nitrogenous substances of the food that were not digested in the alimentary tract.

The digestive solution used contained 1.25 grams of pepsin per liter of 0.33 per cent hydrochloric acid. The weighed sample of feces was placed in a flask with 100 cubic centimeters of this solution and kept for twenty-four hours at 38° to 40° C. The material in the flask was then filtered, and the residue was thoroughly washed and dried upon the filter paper. The top of the paper was then cut off to get rid of any soluble material dried there and the remainder containing the undissolved residue was dropped into a Kjeldahl flask and the nitrogen was then determined in the usual manner.

The nitrogen in the material not dissolved by the pepsin solution was considered as pertaining to the protein of the food that escaped digestion, and the actual digestibility of the nitrogen was computed

from the amount consumed in the food, and that thus determined for undigested material. These figures are summarized in Table 22. The coefficients thus obtained for digestibility of nitrogen are of course practically the same as for protein, since this is the only source of nitrogen in the food.

In addition to the data for total diet, the actual digestibility of the protein of the meat alone has also been estimated. This was done by assuming that 2 per cent of the nitrogen of the milk and 5 per cent of that of the bread eaten with the meat would be accounted for in the undigested food residue. This factor for bread nitrogen was derived from the results of digestion experiments with bread by Woods,<sup>a</sup> in which he computed the actual digestibility of the bread protein according to the same method as here followed for the meat.

TABLE 22.—*Metabolic nitrogen in feces as determined by treatment with pepsin solution, experiments Nos. 290-301, 368-387, 419-430.*

Ex- periment No.	Sub- ject.	Kind of food,	Nitro- gen in food.	Air- dried feces.	Nitrogen in total feces.	Nitrogen in feces undis- solved by pep- sin solution.	Nitrogen di- gested.
290	A	Beef, bread, butter;					
		Entire diet.....	Grams.	Grams.	Per ct.	Grams.	Per ct.
291	B	Meat alone.....	36.09	43.38	6.32	3.03	2.88
		Entire diet.....	28.95	.....	.....	2.02	.....
292	B	Beef, bread, milk;					
		Entire diet.....	48.44	38.29	4.49	1.68	2.39
293	A	Meat alone.....	38.73	.....	.....	.74	.....
		Beef, bread, butter;					
294	B	Entire diet.....	46.75	23.98	5.44	1.30	2.14
		Meat alone.....	40.32	.....	.....	.36	.....
295	A	Beef, bread, butter;					
		Entire diet.....	34.51	38.75	6.21	3.03	2.71
296	B	Meat alone.....	26.92	.....	.....	1.30	.....
		Beef, bread, butter;					
297	D	Entire diet.....	38.55	27.10	4.17	1.13	2.22
		Meat alone.....	32.24	.....	.....	.20	.....
298	E	Beef, bread, butter,					
		milk;					
299	B	Entire diet.....	25.83	18.04	4.52	.82	2.14
		Meat alone.....	16.42	.....	.....	.....	.....
300	E	Beef, bread, butter,					
		milk;					
301	B	Entire diet.....	33.24	18.85	4.11	.83	2.01
		Meat alone.....	21.70	.....	.....	.....	.....
308	E	Beef, bread, butter,					
		milk;					
309	E	Entire diet.....	60.57	21.50	4.39	.94	1.63
		Meat alone.....	43.90	.....	.....	.46	.....
310	B	Beef, bread, butter,					
		milk;					
311	E	Entire diet.....	85.68	62.05	4.68	2.90	1.43
		Meat alone.....	51.66	.....	.....	.99	.....
312	B	Beef, bread, butter,					
		milk;					
313	E	Entire diet.....	61.86	52.00	3.60	1.87	1.63
		Meat alone.....	44.28	.....	.....	.54	.....
314	B	Beef, bread, milk;					
		Entire diet.....	76.54	55.60	4.51	2.51	1.27
315	E	Meat alone.....	50.48	.....	.....	1.24	.....
		Beef, bread, butter,					
316	F	milk;					
		Entire diet.....	64.92	37.61	4.77	1.79	1.54
317	E	Meat alone.....	46.09	.....	.....	.76	.....
		Beef, bread, butter,					
318	F	milk;					
		Entire diet.....	70.47	75.76	3.94	2.98	1.40
319	E	Meat alone.....	50.65	.....	.....	1.52	.....
		Beef, bread, milk;					
320	E	Entire diet.....	72.85	67.32	4.43	2.98	1.24
		Meat alone.....	50.65	.....	.....	1.64	.....
321	B	Beef, bread, milk;					
		Entire diet.....	64.31	40.76	4.82	1.96	1.41
322	B	Meat alone.....	54.27	.....	.....	1.05	.....

<sup>a</sup> U. S. Dept. Agr., Office of Experiment Stations Buls. 85 and 143.

TABLE 22.—Metabolic nitrogen in feces as determined by treatment with pepsin solution, experiments Nos. 290-301, 368-387, 419-430—Continued.

Ex- periment No.	Sub- ject.	Kind of food,	Nitro- gen in food,	Air- dried feces,	Nitrogen in total feces,	Nitrogen in feces indis- solved by pep- sin solution,	Nitrogen di- gested,
371	F	Beef, bread, butter, milk:					
		Entire diet.....	73.91	59.83	4.80	2.87	2.18
		Meat alone.....	50.09	.....	.....	1.23	.....
372	E	Beef, bread, milk:					
		Entire diet.....	82.11	40.52	5.59	2.27	1.83
		Meat alone.....	54.65	.....	.....	1.36	.....
373	B	Beef, bread, milk:					
		Entire diet.....	70.56	42.18	4.39	1.85	2.00
		Meat alone.....	54.65	.....	.....	1.95	.....
374	F	Beef, bread, butter milk:					
		Entire diet.....	69.27	54.26	4.56	2.47	1.94
		Meat alone.....	43.48	.....	.....	1.88	.....
375	E	Beef, bread, milk:					
		Entire diet.....	71.60	65.63	4.86	3.19	1.77
		Meat alone.....	48.92	.....	.....	1.96	.....
376	B	Beef, bread, milk:					
		Entire diet.....	61.93	42.21	3.36	1.42	1.54
		Meat alone.....	38.05	.....	.....	1.36	.....
377	F	Beef, bread, butter, milk:					
		Entire diet.....	81.47	35.01	4.56	1.59	2.09
		Meat alone.....	57.16	.....	.....	1.32	.....
378	E	Beef, bread, milk:					
		Entire diet.....	70.20	37.04	4.94	1.73	1.63
		Meat alone.....	47.63	.....	.....	1.69	.....
379	B	Beef, bread, milk:					
		Entire diet.....	77.42	27.78	3.64	1.01	1.32
		Meat alone.....	57.16	.....	.....	1.02	.....
380	H	Veal, bread, milk:					
		Entire diet.....	79.52	45.56	6.47	2.95	2.05
		Meat alone.....	58.50	.....	.....	1.87	.....
381	H	Mutton, bread, milk:					
		Entire diet.....	73.40	73.85	5.12	3.78	1.54
		Meat alone.....	49.62	.....	.....	2.36	.....
382	I	Veal, bread, butter, milk:					
		Entire diet.....	101.18	56.00	6.10	3.42	2.29
		Meat alone.....	71.99	.....	.....	1.44	.....
383	B	Veal, bread, butter, milk:					
		Entire diet.....	69.39	34.42	4.61	1.59	1.93
		Meat alone.....	53.99	.....	.....	1.53	.....
384	I	Mutton, bread, butter, milk:					
		Entire diet.....	92.57	72.12	4.89	3.53	1.47
		Meat alone.....	62.38	.....	.....	1.32	.....
385	B	Mutton, bread, butter, milk:					
		Entire diet.....	80.20	53.29	3.41	1.82	1.44
		Meat alone.....	51.05	.....	.....	1.03	.....
386	I	Pork, bread, butter, milk:					
		Entire diet.....	90.43	39.69	5.16	2.05	1.75
		Meat alone.....	56.01	.....	.....	1.03	.....
387	B	Pork, bread, butter, milk:					
		Entire diet.....	79.05	44.73	3.81	1.70	1.42
		Meat alone.....	50.91	.....	.....	1.03	.....
419	H	Veal, bread, milk:					
		Entire diet.....	72.17	39.79	5.35	2.13	1.26
		Meat alone.....	45.41	.....	.....	1.60	.....
420	I	Veal, bread, butter, milk:					
		Entire diet.....	79.05	25.73	3.99	1.03	1.14
		Meat alone.....	49.95	.....	.....	1.29	.....
421	B	Veal, bread, butter, milk:					
		Entire diet.....	67.36	26.87	3.52	1.94	1.28
		Meat alone.....	45.41	.....	.....	1.34	.....
422	I	Beef ribs, bread, but- ter, milk:					
		Entire diet.....	67.47	59.48	3.40	2.02	1.88
		Meat alone.....	35.27	.....	.....	1.53	.....
423	B	Beef ribs, bread, but- ter, milk:					
		Entire diet.....	65.45	60.97	2.90	1.77	1.94
		Meat alone.....	35.27	.....	.....	1.57	.....

TABLE 22. *Metabolic nitrogen in feces as determined by treatment with pepsin solution.* Experiments Nos. 290-301, 368-387, 419-430—Continued.

Ex- periment No.	Sub- ject.	Kind of food.	Nitro- gen in food.	Air- dried fees.	Nitrogen in total fees.	Nitrogen in fees indis- solved by pep- sin solution.	Nitrogen di- gested.
421	I	Ham, bread, butter, milk:					
		Entire diet.....	Grams.	Grams.	Per cent.	Grams.	Per cent.
		62.62	28.70	4.79	1.38	1.71	0.49
		Meat alone.....	40.21	.....	.....	0.06	.....
425	I	Ham, bread, butter, milk:					
		Entire diet.....	Grams.	Grams.	Per cent.	Grams.	Per cent.
		69.10	43.25	4.96	2.14	1.04	.45
		Meat alone.....	41.76	.....	.....	.21	.....
426	B	Beef ribs, bread, but- ter, milk:					
		Entire diet.....	Grams.	Grams.	Per cent.	Grams.	Per cent.
		72.36	51.62	2.85	1.46	.98	.50
		Meat alone.....	43.36	.....	.....	.....	.....
427	J	Beef ribs, bread, but- ter, milk:					
		Entire diet.....	Grams.	Grams.	Per cent.	Grams.	Per cent.
		84.85	25.62	3.09	1.02	1.39	.36
		Meat alone.....	59.14	.....	.....	.....	.....
428	I	Beef ribs, bread, but- ter, milk:					
		Entire diet.....	Grams.	Grams.	Per cent.	Grams.	Per cent.
		54.73	38.30	4.20	1.61	1.27	.49
		Meat alone.....	36.19	.....	.....	.37	.....
429	B	Beef ribs, bread, but- ter, milk:					
		Entire diet.....	Grams.	Grams.	Per cent.	Grams.	Per cent.
		67.98	23.35	4.74	1.11	2.35	.55
		Meat alone.....	41.59	.....	.....	.....	.....
430	J	Beef ribs, bread, but- ter, milk:					
		Entire diet.....	Grams.	Grams.	Per cent.	Grams.	Per cent.
		85.16	56.48	5.64	3.17	1.62	.91
		Meat alone.....	60.49	.....	.....	.25	.....

The above data are summarized in Table 23, the results for similar experiments being brought together and averaged.

TABLE 23. *Coefficients of digestibility of protein after correction for metabolic products.*

Ex- periment No.	Sub- ject.	Kind of meat.	Protein digested in—	
			Total food.	Meat alone.
293	A	Lean beef round, cooked in water at 80° to 85° C., for 1 hour.....	Per cent.	Per cent.
294	B	do.....	96.96	97.55
297	D	do.....	98.44	99.16
300	E	do.....	99.42	100.00
301	B	do.....	99.07	100.00
		Average.....	99.11	100.00
			98.60	99.34
299	A	Lean beef round, cooked in water at 80° to 85° C., for 2 hours....	96.07	96.44
301	B	do.....	98.10	98.66
302	B	do.....	98.30	99.67
308	E	do.....	98.96	100.00
299	B	do.....	98.63	99.41
		Average.....	98.13	98.84
295	A	Lean beef round, cooked in water at 80° to 85° C., for 3 hours....	98.53	100.00
296	B	do.....	98.89	100.00
		Average.....	98.66	100.00
371	F	Lean beef round pan broiled.....	98.24	98.24
372	E	do.....	99.10	100.00
373	B	do.....	98.81	99.30
		Average.....	98.72	99.18
374	F	Lean beef round fried in hot lard.....	98.48	99.38
375	E	do.....	98.38	98.96
376	B	do.....	98.95	99.92
		Average.....	98.60	99.42

TABLE 23.—*Coefficients of digestibility of protein after correction for metabolic products.*  
Continued.

Ex- per- imental No.	Sub- ject.	Kind of meat.	Protein digested in	
			Total food.	Meat alone.
377	F	Lean beef round roasted . . . . .	Per cent.	Per cent.
378	E	.....do.....	99.10	99.91
379	B	.....do.....	99.19	100.00
		Average.....	99.52	100.00
			99.27	99.97
388	F	Fat beef shoulder cooked in water at 80° to 85° C. for 2 hours. . . . .	98.50	99.23
389	E	.....do.....	98.86	99.68
370	B	.....do.....	99.11	99.65
		Average.....	98.82	99.52
422	I	Beef ribs roasted . . . . .	99.21	100.00
423	B	.....do.....	99.13	100.00
426	B	.....do.....	99.31	100.00
427	J	.....do.....	99.58	100.00
428	B	.....do.....	99.10	100.00
429	B	.....do.....	99.19	100.00
430	J	.....do.....	98.93	99.90
		Average.....	99.20	99.99
380	H	Veal leg roasted . . . . .	98.82	99.40
382	I	.....do.....	98.74	99.61
383	B	.....do.....	99.05	99.69
419	H	.....do.....	99.31	100.00
420	I	.....do.....	99.63	100.00
421	B	.....do.....	99.50	100.00
		Average.....	99.48	99.78
381	H	Mutton leg roasted . . . . .	98.45	99.15
384	I	.....do.....	98.86	99.92
385	B	.....do.....	99.04	100.00
		Average.....	98.78	99.69
386	I	Pork, fresh ham, roasted . . . . .	99.24	100.00
387	B	.....do.....	99.19	100.00
424	I	.....do.....	99.22	100.00
425	J	.....do.....	99.35	100.00
		Average.....	99.25	100.00

The actual digestibility of the protein of the total diet and of the meat alone, as shown by the figures in Table 23, is high. The figures for meat alone would indicate that practically all of the protein of the meat was digested. This is not at all improbable, though it should be stated that severe criticism of the method by which the data were derived would suggest that such a conclusion can not be drawn without some qualification. It is not certain that the pepsin solution, even though very weak, would digest only the nitrogenous materials from the metabolic products of the feces, and leave all of the undigested food protein unaffected; possibly some of the latter might be dissolved also. Furthermore, it is possible that the undigested meat protein would be more affected than that from bread, as experiments indicate that artificial digestive solutions act more readily upon the former than upon the latter. Nevertheless, the authors are inclined to believe, in the light of results obtained in artificial digestion of meat, that the results shown in Table 23 are not far from the truth, and that the actual digestibility of meat protein is near 100 per cent.

**INCOME AND OUTGO OF NITROGEN AND GAIN OR LOSS OF PROTEIN.**

In each digestion experiment the urine of the subject was collected for each twenty-four hours, and the quantity of nitrogen in it determined by the Kjeldahl method. At a certain hour on the first day of each experiment the urine was voided and rejected, then all that was eliminated up to the same hour the next day was collected for the day's output. In most of the experiments the urine periods began at 7 a. m., but in experiments Nos. 275 to 282 they began at 1 p. m. In each case the final period ended at the corresponding hour on the first day following the experiment. In experiments Nos. 284 to 289 the urine was collected in six-hour periods, and the nitrogen in it determined for each period.

The urine data for the different experiments are given in Table 24, showing the total weight of urine for each day and the percentage and amount of nitrogen in it, except that in experiments Nos. 284 to 289, in which the determinations were made in six-hour periods, the percentage of nitrogen in the daily urine is not given, the total weight of urine and quantity of nitrogen for the day being the sums of the corresponding data for the six-hour periods. The table also shows the total quantity of nitrogen in the urine, in the feces, and in the food for each experimental period, and the apparent gain or loss of nitrogen and protein by the body, the protein being computed from the estimated gain or loss of nitrogen in the usual manner, by multiplying by the factor 6.25.

TABLE 24.—*Quantity and nitrogen content of urine per day, total income and outgo of nitrogen, and apparent gain or loss of protein, in experiments Nos. 267-301, 368-387, 399-429.*

Experiment No.	Subject	Kind of food.	Days of experiment	Weight of urine.	Quantity of nitrogen in daily urine.	Total quantity of nitrogen in		Apparent gain (+) or loss (-) to body.			
						Urine.	Feces.	Food.	Nitrogen.		
267 A		Mixed diet, including lean beef pan broiled.	1	871.4	1.43	12.46	-----	-----	-----		
			2	603.5	1.09	11.72	-----	-----	-----		
			3	713.8	1.67	11.92	-----	-----	-----		
			4	608.6	1.62	11.32	-----	-----	-----		
Total, . . . . .				2,977.0	-----	-----	47.42	3.92	47.80		
. . . . .								+3.54	-22.13		
268 B		Mixed diet, including lean beef pan broiled.	1	645.0	1.94	12.51	-----	-----	-----		
			2	836.3	1.61	13.46	-----	-----	-----		
			3	841.1	1.66	13.80	-----	-----	-----		
			4	862.2	1.62	13.97	-----	-----	-----		
Total, . . . . .				2,594.1	-----	-----	53.74	4.36	63.84		
. . . . .								+5.75	+35.95		
269 A		Mixed diet, including lean beef pan broiled.	1	648.9	1.53	9.93	-----	-----	-----		
			2	768.3	1.40	10.76	-----	-----	-----		
			3	769.5	1.33	10.34	-----	-----	-----		
Total, . . . . .				2,186.7	-----	-----	31.03	2.82	34.59		
. . . . .								+74	+4.63		

TABLE 24.—Quantity and nitrogen content of urine per day, total income and outgo of nitrogen, and apparent gain or loss of protein, etc.—Continued.

Experiment No.	Subject	Kind of food.	Days of experiment.	Weight of urine.	Quantity of nitrogen in daily urine.	Total quantity of nitrogen in		Apparent gain (+) or loss (-) to body.	
						Urine.	Feces.	Food.	Nitrogen.
270	B	Mixed diet, including lean beef pan broiled	1	748.4	1.70	12.72	.....	.....	.....
			2	666.5	1.58	10.53	.....	.....	.....
			3	835.2	1.71	14.28	.....	.....	.....
		Total, . . . . .		2,250.1	.....	.....	37.53	3.09	47.77 +7.15 +44.69
271	A	Mixed diet, including lean beef cooked in water 2 hours	1	644.1	1.33	8.57	.....	.....	.....
			2	916.2	1.45	10.54	.....	.....	.....
			3	680.8	1.60	10.89	.....	.....	.....
			4	793.2	1.46	11.58	.....	.....	.....
		Total, . . . . .		3,034.3	.....	.....	41.58	3.96	51.59 +6.05 +37.81
272	B	Mixed diet, including lean beef cooked in water 2 hours	1	735.9	1.22	8.98	.....	.....	.....
			2	739.3	1.46	10.79	.....	.....	.....
			3	726.8	1.61	11.70	.....	.....	.....
			4	917.1	1.57	14.40	.....	.....	.....
		Total, . . . . .		3,119.1	.....	.....	45.87	2.96	66.48 +17.55 +110.32
273	A	Mixed diet, including lean beef cooked in water 4 hours	1	809.4	1.23	9.97	.....	.....	.....
			2	693.0	1.55	10.74	.....	.....	.....
			3	630.3	1.66	10.46	.....	.....	.....
			4	747.4	1.54	11.51	.....	.....	.....
		Total, . . . . .		2,880.1	.....	.....	42.68	2.00	49.31 +4.03 +25.19
274	B	Mixed diet, including lean beef cooked in water 4 hours	1	804.2	1.38	11.10	.....	.....	.....
			2	805.4	1.47	11.84	.....	.....	.....
			3	803.5	1.62	13.02	.....	.....	.....
			4	755.0	1.89	14.27	.....	.....	.....
		Total, . . . . .		3,168.1	.....	.....	50.23	2.55	64.46 +11.68 +73.01
275	B	Mixed diet, including lean beef cooked in water 2 hours	1	1,203.6	1.29	15.53	.....	.....	.....
			2	821.3	1.93	15.85	.....	.....	.....
			3	1,219.8	1.48	18.05	.....	.....	.....
			4	1,149.7	1.22	14.03	.....	.....	.....
		Total, . . . . .		4,394.4	.....	.....	63.46	3.53	59.40 -7.59 -47.40
276	B	Mixed diet, including lean beef cooked in water 2 hours	1	797.8	1.88	15.00	.....	.....	.....
			2	846.2	1.93	16.33	.....	.....	.....
			3	924.0	1.79	16.54	.....	.....	.....
			4	1,607.4	1.01	16.24	.....	.....	.....
		Total, . . . . .		4,175.4	.....	.....	64.11	4.79	63.41 -5.49 -34.30
277	B	Mixed diet, including lean beef cooked in water 2 hours	1	757.4	1.92	14.54	.....	.....	.....
			2	866.3	1.87	16.20	.....	.....	.....
			3	938.6	1.73	16.24	.....	.....	.....
			4	849.9	1.83	15.55	.....	.....	.....
		Total, . . . . .		3,412.2	.....	.....	62.53	2.50	57.07 -7.96 -49.80
278	B	Mixed diet, including lean beef fried	1	785.5	1.89	14.85	.....	.....	.....
			2	858.5	1.75	15.02	.....	.....	.....
			3	855.3	1.59	13.60	.....	.....	.....
			4	825.5	1.69	13.95	.....	.....	.....
		Total, . . . . .		3,324.8	.....	.....	57.42	2.02	53.45 -5.99 -37.40
279	B	Mixed diet, including lean beef fried	1	770.8	1.55	11.95	.....	.....	.....
			2	846.8	1.64	13.88	.....	.....	.....
			3	954.1	1.45	13.84	.....	.....	.....
			4	862.5	1.49	12.85	.....	.....	.....
		Total, . . . . .		3,434.2	.....	.....	52.52	1.57	52.54 -1.55 -9.65
280	B	Mixed diet, including lean beef cooked in water 20 minutes	1	661.4	1.84	12.26	.....	.....	.....
			2	1,044.2	1.45	15.14	.....	.....	.....
			3	997.6	1.29	12.87	.....	.....	.....
			4	884.8	1.60	14.16	.....	.....	.....
		Total, . . . . .		3,588.0	.....	.....	54.43	2.93	53.56 -3.80 -23.80

TABLE 24.—Quantity and nitrogen content of urine per day, total income and outgo of nitrogen, and apparent gain or loss of protein, etc.—Continued.

Experiment No.	Subject	Kind of food.	Days of experiment	Weight of urine.	Quantity of nitrogen in daily urine.	Total quantity of nitrogen in—		Apparent gain (+) or loss (-) to body.	
						Urine.	Feces.	Food.	Nitrogen.
281	B	Mixed diet, including lean beef cooked in water 20 minutes.....	1 2 3 4	Grams.	Prct.	Grams.	Grams.	Grams.	Grams.
				779.5	1.55	12.08	.....	.....	.....
				908.5	1.62	14.72	.....	.....	.....
				1,052.8	1.41	14.84	.....	.....	.....
			Total.....	796.9	1.71	13.63	.....	.....	.....
282	B	Mixed diet, including lean beef cooked by broiling 20 minutes.....	1 2 3 4	Grams.	Prct.	Grams.	Grams.	Grams.	Grams.
				792.4	1.37	10.86	.....	.....	.....
				1,054.3	1.28	13.50	.....	.....	.....
				901.0	1.37	12.34	.....	.....	.....
			Total.....	792.9	1.51	11.97	.....	.....	.....
284	C	Mixed diet, including lean beef cooked in water 2 hours.....	1 2 3 4	Grams.	Prct.	Grams.	Grams.	Grams.	Grams.
				784.5	.....	13.59	.....	.....	.....
				1,380.3	.....	14.91	.....	.....	.....
				1,174.2	.....	16.82	.....	.....	.....
			Total.....	1,296.2	.....	16.77	.....	.....	.....
285	C	Mixed diet, including lean beef cooked in water 2 hours.....	1 2 3 4	Grams.	Prct.	Grams.	Grams.	Grams.	Grams.
				789.7	.....	16.07	.....	.....	.....
				782.0	.....	17.69	.....	.....	.....
				903.6	.....	19.93	.....	.....	.....
			Total.....	837.3	.....	18.09	.....	.....	.....
286	C	Mixed diet, including lean beef cooked in water 2 hours.....	1 2 3 4 5	Grams.	Prct.	Grams.	Grams.	Grams.	Grams.
				1,515.1	.....	13.44	.....	.....	.....
				1,047.9	.....	15.55	.....	.....	.....
				972.8	.....	16.21	.....	.....	.....
				1,051.7	.....	17.09	.....	.....	.....
			Total.....	393.8	1.13	4.45	.....	.....	.....
287	C	Mixed diet, including lean beef cooked in water 2 hours.....	1 2 3 4	Grams.	Prct.	Grams.	Grams.	Grams.	Grams.
				1,228.5	.....	16.65	.....	.....	.....
				1,310.0	.....	16.58	.....	.....	.....
				1,250.5	.....	16.69	.....	.....	.....
			Total.....	1,060.5	.....	16.06	.....	.....	.....
288	C	Mixed diet, including lean beef cooked in water 2 hours.....	1 2 3 4	Grams.	Prct.	Grams.	Grams.	Grams.	Grams.
				912.7	.....	14.26	.....	.....	.....
				839.3	.....	15.59	.....	.....	.....
				756.5	.....	15.68	.....	.....	.....
			Total.....	854.3	.....	16.46	.....	.....	.....
289	C	Mixed diet, including lean beef cooked in water 2 hours.....	1 2 3 4	Grams.	Prct.	Grams.	Grams.	Grams.	Grams.
				822.9	.....	15.98	.....	.....	.....
				848.8	.....	16.49	.....	.....	.....
				873.0	.....	17.23	.....	.....	.....
			Total.....	934.2	.....	16.45	.....	.....	.....
293	A	Simple diet, including lean beef round, cooked in water at 80-85° C. for 1 hour....	1 2	Grams.	Prct.	Grams.	Grams.	Grams.	Grams.
				884.6	1.85	16.37	.....	.....	.....
				922.7	2.03	18.73	.....	.....	.....
			Total.....	1,807.3	.....	.....	35.60	3.03	34.51
								-3.62	-11.38
294	B	Simple diet, including lean beef round, cooked in water at 80-85° C. for 1 hour....	1 2	Grams.	Prct.	Grams.	Grams.	Grams.	Grams.
				994.2	1.61	16.01	.....	.....	.....
				995.3	1.96	19.51	.....	.....	.....
			Total.....	1,989.5	.....	.....	35.52	1.13	38.55
								+1.90	+ 5.94

TABLE 24.—Quantity and nitrogen content of urine per day, total income and outgo of nitrogen, and apparent gain or loss of protein, etc.—Continued.

Experiment No.	Subject	Kind of food.	Days of experiment	Weight of urine.	Quantity of nitrogen in daily urine.	Total quantity of nitrogen in—			Apparent gain (+) or loss (-) to body.	
						Urine.	Feces.	Food.	Nitrogen.	Protein.
297	D	Simple diet, including lean beef round, cooked in water at 80-85° C. for 1 hour.	{ 1 2 3 }	Grams. 959.2 1,083.6 1,183.0	Pr. ct. 1.29 1.98 2.23	Grams. 12.37 21.46 26.38	Grams. ..... ..... .....	Grams. ..... ..... .....	Grams. ..... ..... .....	Grams. ..... ..... .....
		Total.....		3,225.8	.....	60.21	0.94	60.57	-0.58	-1.19
300	E	Simple diet, including lean beef round, cooked in water at 80-85° C. for 1 hour.	{ 1 2 3 }	Grams. 1,173.0 1,361.1 1,260.1	Pr. ct. 1.53 1.81 2.04	Grams. 17.95 24.64 25.71	Grams. ..... ..... .....	Grams. ..... ..... .....	Grams. ..... ..... .....	Grams. ..... ..... .....
		Total.....		3,794.2	.....	68.30	2.51	76.54	+1.91	+11.94
301	B	Simple diet, including lean beef round, cooked in water at 80-85° C. for 1 hour.	{ 1 2 3 }	Grams. 1,094.4 1,112.9 1,069.1	Pr. ct. 1.51 1.96 2.05	Grams. 16.53 21.81 21.92	Grams. ..... ..... .....	Grams. ..... ..... .....	Grams. ..... ..... .....	Grams. ..... ..... .....
		Total.....		3,276.4	.....	60.26	1.79	64.92	+.96	+6.00
290	A	Simple diet, including lean beef round, cooked in water at 80-85° C. for 2 hours.	{ 1 2 }	Grams. 823.6 1,134.2	Pr. ct. 2.04 1.66	Grams. 16.80 18.83	Grams. ..... .....	Grams. ..... .....	Grams. ..... .....	Grams. ..... .....
		Total.....		1,957.8	.....	35.63	3.06	36.08	-1.31	-8.19
291	B	Simple diet, including lean beef round, cooked in water at 80-85° C. for 2 hours.	{ 1 2 }	Grams. 1,083.3 1,166.3	Pr. ct. 1.60 2.05	Grams. 17.33 23.91	Grams. ..... .....	Grams. ..... .....	Grams. ..... .....	Grams. ..... .....
		Total.....		2,249.6	.....	41.24	1.68	48.41	+2.76	+17.25
292	B	Simple diet, including lean beef round, cooked in water at 80-85° C. for 2 hours.	{ 1 2 }	Grams. 1,165.5 1,078.6	Pr. ct. 1.76 2.04	Grams. 20.48 21.94	Grams. ..... .....	Grams. ..... .....	Grams. ..... .....	Grams. ..... .....
		Total.....		2,244.1	.....	42.42	1.30	46.75	+1.51	+9.43
298	E	Simple diet, including lean beef round, cooked in water at 80-85° C. for 2 hours.	{ 1 2 3 }	Grams. 1,259.4 1,314.4 1,350.2	Pr. ct. 1.79 1.99 2.01	Grams. 22.54 26.16 27.14	Grams. ..... ..... .....	Grams. ..... ..... .....	Grams. ..... ..... .....	Grams. ..... ..... .....
		Total.....		3,294.0	.....	75.84	2.90	85.68	+2.31	+14.44
299	B	Simple diet, including lean beef round, cooked in water at 80-85° C. for 2 hours.	{ 1 2 3 }	Grams. 884.9 927.3 980.1	Pr. ct. 1.78 2.10 2.15	Grams. 15.75 19.47 21.07	Grams. ..... ..... .....	Grams. ..... ..... .....	Grams. ..... ..... .....	Grams. ..... ..... .....
		Total.....		2,792.3	.....	56.29	1.87	61.88	+1.23	+7.69
295	A	Simple diet, including lean beef round, cooked in water at 80-85° C. for 3 hours.	{ 1 2 }	Grams. Lost. 936.8	Pr. ct. 1.75	Grams. 16.39	Grams. ..... .....	Grams. ..... .....	Grams. ..... .....	Grams. ..... .....
		Total.....		.....	.....	.....	.82	25.83	-3.89	-24.31
296	B	Simple diet, including lean beef round, cooked in water at 80-85° C. for 3 hours.	{ 1 2 }	Grams. 774.0 810.8	Pr. ct. 2.03 2.24	Grams. 15.71 18.16	Grams. ..... .....	Grams. ..... .....	Grams. ..... .....	Grams. ..... .....
		Total.....		1,584.8	.....	33.87	.83	33.24	-.74	-4.63

TABLE 24. *Quality and nitrogen content of maize dry total income and area of cultivation, at different prices of maize, etc.* Continued

TABLE 24.—Quantity and nitrogen content of urine per day, total income and outgo of nitrogen, and apparent gain or loss of protein, etc.—Continued.

Experiment No.	Subject	Kind of food.	Days of experiment	Weight of urine.	Quantity of nitrogen in daily urine.	Total quantity of nitrogen in—		Apparent gain (+) or loss (-) to body.	
						Urine.	Feces.	Food.	Nitrogen.
370	B	Simple diet, including fat beef saucier, cooked in water at 80-85° C. for 2 hours.	[1] 1 [2] 2 [3] 3	Grams.	Pr. ct.	Grams.	Grams.	Grams.	Grams.
						1,192.9	1.85	20.40	.....
						995.1	2.26	22.49	.....
						867.7	2.56	20.48	.....
		Total.....		2,965.7	.....	63.37	1.96	64.31	-0.34 -2.43
422	I	Simple diet, including beef ribs, roasted.....	[1] 1 [2] 2 [3] 3	Grams.	Pr. ct.	Grams.	Grams.	Grams.	Grams.
						1,176.9	1.87	22.01	.....
						1,046.3	1.84	19.25	.....
						918.9	1.94	17.83	.....
		Total.....		3,142.1	.....	59.69	2.02	67.47	+2.42 +13.25
423	B	Simple diet, including beef ribs, roasted.....	[1] 1 [2] 2 [3] 3	Grams.	Pr. ct.	Grams.	Grams.	Grams.	Grams.
						996.3	1.88	18.73	.....
						1,029.5	2.12	21.83	.....
						1,099.5	1.81	19.90	.....
		Total.....		3,125.3	.....	60.46	1.77	65.45	+1.07 +6.69
426	B	Simple diet, including beef ribs, roasted.....	[1] 1 [2] 2 [3] 3	Grams.	Pr. ct.	Grams.	Grams.	Grams.	Grams.
						1,194.0	1.76	21.02	.....
						1,164.5	1.88	21.89	.....
						1,115.0	2.03	22.63	.....
		Total.....		3,473.5	.....	65.54	1.46	72.36	+1.79 +11.19
427	J	Simple diet, including beef ribs, roasted.....	[1] 1 [2] 2 [3] 3	Grams.	Pr. ct.	Grams.	Grams.	Grams.	Grams.
						1,524.4	1.53	23.32	.....
						1,556.3	1.65	25.55	.....
						1,502.7	1.73	27.55	.....
		Total.....		4,653.4	.....	76.22	1.02	84.85	+2.54 +15.88
428	I	Simple diet, including beef ribs, roasted.....	[1] 1 [2] 2 [3] 3	Grams.	Pr. ct.	Grams.	Grams.	Grams.	Grams.
						843.0	1.96	16.52	.....
						897.5	2.07	18.58	.....
						930.4	2.08	19.57	.....
		Total.....		2,680.9	.....	54.67	1.61	54.73	- .52 -3.25
429	B	Simple diet, including beef ribs, roasted.....	[1] 1 [2] 2 [3] 3	Grams.	Pr. ct.	Grams.	Grams.	Grams.	Grams.
						1,118.6	1.78	19.13	.....
						1,053.0	2.02	21.27	.....
						988.0	2.14	21.14	.....
		Total.....		3,159.6	.....	61.54	1.11	67.98	+1.78 +11.13
430	J	Simple diet, including beef ribs, roasted.....	[1] 1 [2] 2 [3] 3	Grams.	Pr. ct.	Grams.	Grams.	Grams.	Grams.
						1,226.7	1.88	23.06	.....
						1,305.6	1.95	25.59	.....
						1,715.9	1.54	26.43	.....
		Total.....		4,248.2	.....	74.99	3.17	85.16	+2.53 +14.56
380	H	Simple diet, including veal leg, roasted.....	[1] 1 [2] 2 [3] 3	Grams.	Pr. ct.	Grams.	Grams.	Grams.	Grams.
						978.5	2.22	21.72	.....
						1,361.1	2.18	29.67	.....
						1,240.6	2.31	28.66	.....
		Total.....		2,580.2	.....	80.05	2.95	79.72	-1.16 -7.25
382	I	Simple diet, including veal leg, roasted.....	[1] 1 [2] 2 [3] 3	Grams.	Pr. ct.	Grams.	Grams.	Grams.	Grams.
						1,315.1	2.06	27.09	.....
						1,288.0	2.09	26.92	.....
						1,489.2	2.27	33.69	.....
		Total.....		4,083.3	.....	87.61	3.42	101.18	+3.58 +21.13
383	B	Simple diet, including veal leg, roasted.....	[1] 1 [2] 2 [3] 3	Grams.	Pr. ct.	Grams.	Grams.	Grams.	Grams.
						1,090.3	1.81	19.73	.....
						1,180.2	2.00	23.01	.....
						1,177.9	2.07	24.38	.....
		Total.....		3,448.4	.....	67.72	1.59	69.49	+ .03 + .19
419	H	Simple diet, including veal leg, roasted.....	[1] 1 [2] 2 [3] 3	Grams.	Pr. ct.	Grams.	Grams.	Grams.	Grams.
						972.0	2.19	21.29	.....
						995.7	2.23	22.20	.....
						1,152.5	2.35	27.09	.....
		Total.....		3,120.2	.....	70.78	2.13	72.17	- .18 -1.13
420	I	Simple diet, including veal leg, roasted.....	[1] 1 [2] 2 [3] 3	Grams.	Pr. ct.	Grams.	Grams.	Grams.	Grams.
						1,246.4	2.04	25.43	.....
						1,040.9	2.26	22.90	.....
						1,115.0	2.17	24.20	.....
		Total.....		3,402.3	.....	72.53	1.03	79.05	+1.83 +11.44

TABLE 24. *Quantity and nitrogen content of urine per day, total income and outgo of nitrogen, and apparent gain or loss of protein, etc.* Continued.

Experiment No.	Kind of food.	Weight of urine. $\frac{1}{2}$ gm. $\frac{1}{2}$ gm.	Quantity of nitrogen in daily urine.	Total quantity of nitrogen in-		Apparent gain (+) or loss (-) to body.	
				Urine.	Feces.	Food.	Nitro- gen.
421	B Simple diet, including veal leg, roasted . . . .	[1] 1,064.8 [2] 1,136.4 [3] 1,184.4	1.90 20.23 1.98 22.50 2.07 24.52	67.25	0.94	67.36	-0.28 = 1.75
	Total . . . . .		3,385.6				
381	H Simple diet, including mutton leg, roasted . . .	[1] 905.8 [2] 1,182.5 [3] 1,142.9	2.27 20.56 2.18 25.78 2.15 24.78				
	Total . . . . .		3,231.2				
384	I Simple diet, including mutton leg, roasted . . .	[1] 1,236.0 [2] 1,481.5 [3] 1,320.5	2.42 26.20 1.98 29.33 2.03 26.99				
	Total . . . . .		4,047.0				
385	B Simple diet, including mutton leg, roasted . . .	[1] 1,110.1 [2] 1,266.5 [3] 880.7	1.61 18.21 1.88 23.81 1.95 17.17				
	Total . . . . .		3,257.3				
386	I Simple diet, including pork (fresh ham), roasted . . . . .	[1] 1,121.3 [2] 1,258.2 [3] 1,132.2	2.18 24.45 2.23 28.06 2.25 25.45				
	Total . . . . .		3,510.7				
387	B Simple diet, including pork (fresh ham), roasted . . . . .	[1] 1,196.7 [2] 1,248.7 [3] 1,083.1	1.91 22.86 2.06 25.72 2.11 22.85				
	Total . . . . .		3,528.5				
424	I Simple diet, including pork (fresh ham), roasted . . . . .	[1] 1,253.4 [2] 1,050.3 [3] 932.2	1.63 20.43 2.22 22.87 2.37 22.09				
	Total . . . . .		3,215.9				
425	J Simple diet, including pork (fresh ham), roasted . . . . .	[1] 1,332.6 [2] 1,542.3 [3] 1,511.1	1.41 18.79 1.31 20.21 1.42 21.46				
	Total . . . . .		4,386.0				
				60.46	2.14	69.10	+2.17 +13.56

No definite conclusion regarding gain or loss of protein can be drawn from the above data, because nothing was known concerning the diets and the income and outgo of nitrogen of the subjects previous to the beginning of the experiment; hence it is impossible to tell to what extent the nitrogen of the urine collected pertains to the food of the experimental period and how much should be ascribed to food eaten previous to the experiment. Furthermore, the lag in the excretion of nitrogen from the experimental diet might extend beyond the time of ending the last urine period. For these reasons the difference between income and outgo of nitrogen has been designated "apparent" gain or loss in the above table. It is believed, however, in the light of present available knowledge concerning the lag in nitrogen excretion,

that the data for the second and third days of the experimental periods show with some approximation to accuracy the actual balance between income and outgo of nitrogen under the conditions of the experiments, and from these some estimate can be formed regarding the balance for the whole period.

The gains and losses were very fluctuating, and there were some noticeable losses and some decidedly large gains of nitrogen. On the whole, the gains were much more numerous than the losses, and the average amount gained was so much greater than that lost that it seems fair to assume that the diets used in the experiments were at least sufficient to supply the needs of the subjects for nitrogen.

## **INVESTIGATIONS ON THE EASE OR RAPIDITY OF DIGESTION OF MEAT.**

The ease or rapidity with which different foods may be digested is of some significance. For instance, two kinds of food may be equal to each other in respect to the quantities of the different nutrients which they contain and the thoroughness with which they may be digested, but one may be more easily digested than the other and consequently in certain circumstances somewhat the more advantageous. Different meats, therefore, or similar kinds of meats cooked in different ways, though in other respects apparently of equal nutritive value, may differ in actual value because of variation in the ease of digestion.

Several investigators have attempted to study the ease or rapidity with which different foods may be digested, and among the investigations are some with meats cooked in various ways. Two methods have been followed in these investigations, one consisting of direct examination of the stomach contents at different periods after eating and the other comprising experiments with artificial digestive solutions. Reference is here made to some of these investigations, but the purpose is to give an idea of the nature of the work that has been undertaken and of the results obtained rather than to include a complete summary of what has been accomplished.

### **EXAMINATION OF STOMACH CONTENTS.**

Among the most famous of such experiments, in which the time of digestion in the stomach of meats prepared in different ways was studied, are those made by Beaumont<sup>a</sup> many years ago. His subject was an otherwise normal man who had been shot through the stomach and whose wound had so healed as to leave a valvular opening into the stomach through which its contents could be observed and removed. Beaumont reports that meats remained in the stomach for the periods given in Table 25.

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<sup>a</sup> The Physiology of Digestion, 2. ed. Burlington, Vt., 1847.

TABLE 25.—*Results of observations on gastric digestion.*

Kind of meat.	Method of cooking.	Mean time of chymification.	Kind of meat.	Method of cooking.	Mean time of chymification.
Turkey, domestic.....	Roasted ..	2 30	Pork, recently salted.....	Fried ..	4 15
Do.....	Boiled ..	2 25	Do.....	Broiled ..	3 15
Beef, fresh, lean, rare.....	Roasted ..	3 00	Do.....	Raw ..	3 00
Beef, fresh, lean, dry.....	do ..	3 30	Do.....	Stewed ..	3 00
Beefsteak .....	Broiled ..	3 00	Mutton, fresh.....	Roasted ..	3 15
Beef with salt only.....	Boiled ..	2 45	Do.....	Broiled ..	3 00
Beef with mustard, etc.....	do ..	3 00	Do.....	Boiled ..	3 00
Beef.....	Fried ..	4 00	Veal, fresh.....	Broiled ..	4 00
Beef, old hard, salted.....	Boiled ..	4 15	Do.....	Fried ..	4 30
Pork, steak.....	Broiled ..	3 15	Fowls, domestic.....	Boiled ..	4 00
Pork, fat and lean.....	Roasted ..	5 15	Do.....	Roasted ..	4 00
Pork, recently salted.....	Boiled ..	4 30			

From experiments with a boy having a gastric fistula, Uffelman<sup>a</sup> drew, in effect, the following conclusions regarding the time of gastric digestion of different kinds of meats: All the observations firmly established the fact that the boy digested raw scraped beef more quickly than finely chopped ham, but not so quickly as roasted beef. The first was undoubtedly more quickly penetrated by the gastric juice. However, it fell apart into minute fibers less easily, and the conclusion may safely be drawn that the digestion of the raw meat took place somewhat more slowly than that of the roasted.

Jessen<sup>b</sup> studied the gastric digestion of raw and cooked beef and raw mutton, veal, and pork. His subject was a healthy man, from whom, by means of a stomach pump, the contents of the stomach were removed at intervals after the food was eaten. He found that 100 grams of the various kinds of meat left the stomach in the time given below:

	Hours.
Beef, raw, shredded.....	2
Beef, boiled, rare.....	2½
Beef, boiled, well done.....	3
Beef, broiled, rare.....	3
Beef, broiled, well done.....	4
Mutton, raw, shredded.....	2
Veal, raw, shredded.....	2½
Pork, raw, shredded.....	3

More recent experiments of similar nature, from which much of the current information regarding the rates of gastric digestion of different foods has been derived, are those by Penzoldt<sup>c</sup> and by Verhaegen.<sup>d</sup>

It will be observed that experiments of this nature show chiefly the length of time that foods remain in the stomach and the time

<sup>a</sup> Deut. Arch. Klin. Med., 20 (1877), p. 535.

<sup>b</sup> Ztschr. Biol., 19 (1883), p. 129.

<sup>c</sup> Deut. Arch. Klin. Med., 51 (1893), p. 535.

<sup>d</sup> Physiologie et Pathologie de la Sécration Gastroïque, Paris, 1898.

required for reduction of the food to the condition of chyme, in which condition it passes to the intestine. But digestion is by no means completed in the stomach. In fact the material from the stomach is acted upon much further by the ferments in the intestine, and these experiments show nothing regarding intestinal digestion.

#### ARTIFICIAL DIGESTION EXPERIMENTS.

Artificial digestion experiments—that is, those in which the action of the digestive juices is studied outside of the body—are open to much the same objection as direct observation of the gastric contents. In the first place, it is impossible to reproduce artificially all the conditions of natural digestion, aside from temperature and strength of the digestive fluids, which aid in dissolving the food, and doubtless for this reason artificial digestion is always slower than natural. Beaumont<sup>a</sup> made such experiments in connection with his natural gastric experiments, and found that to produce the same effect on the food outside of the body as in it required rarely less than twice, and often three and one-half times, as long a period of digestion. Furthermore, artificial-digestion experiments, as most commonly made with pepsin, show nothing of the digestibility of fats, which depends largely on their saponification in the intestines, and, so far as the authors have learned, little work has been done with meats to study the effect of trypsin of the pancreatic juice in breaking down peptones into simpler, more absorbable bodies, so that even as regards the digestibility of protein the results of experiments of this nature must be regarded as incomplete. Nevertheless since Stutzer<sup>b</sup> in 1880 proposed the method of making such experiments, which, considerably revised and elaborated, is still most commonly used, much valuable work of this nature has been done. Very little, however, refers especially to the digestibility of meat prepared in different ways.

Among the earliest artificial digestion experiments with meats were those carried on by Jessen<sup>c</sup> in connection with his study of natural digestion. In these experiments 250 grams of beef from a steer about 2 years old were freed as completely as possible from sinew, fat, gristle, and bone, and similar portions of it were boiled until half done, well boiled, roasted underdone, and well roasted. The cooked meats were then partially dried and samples of each, and also of the raw meat, weighing 25 grams were treated with 400 cubic centimeters of an acid pepsin solution containing in some cases 1 gram and in others 2 grams of pepsin per liter of either 0.1 or 0.2 per cent hydrochloric acid. The digestion was continued for twenty-four hours, with frequent stirring, at a temperature of 37° C. The insoluble

<sup>a</sup> Op. cit., p. 292.

<sup>b</sup> Jour. Landw., 28 (1880), pp. 195, 453.

<sup>c</sup> Ztschr. Biol., 19 (1883), p. 129.

residue was then removed by filtration, dried at 100-110° C. for two to five hours, and weighed. In these tests the following coefficients of digestibility were obtained: Raw beef 77.32, boiled beef underdone 62.02, well-boiled beef 28.20, roasted beef underdone 60.96, and well-roasted beef 31.72 per cent. From these results it was concluded that raw meat was more easily digested than cooked meat.

Chittenden and Cummins<sup>a</sup> made a few experiments on the relative digestibility of raw and cooked meats in connection with artificial digestion experiments with fish. In each case 20 grams of meat either raw or cooked in a steam bath and freed as completely as possible from sinew, fat, skin, and bone were treated in a beaker with 200 cubic centimeters of a digestive solution containing 5 grams of pepsin in 1,000 cubic centimeters of pure hydrochloric acid of exactly 0.2 per cent strength. The digestion was continued for twenty-two hours at a temperature of 38° to 40° C. with occasional stirring. At the end of this period the solution was cooled to 20° C., diluted to 250 cubic centimeters, thoroughly mixed, and then filtered through a dry filter. Of the clear filtrate 50 cubic centimeters were evaporated to dryness in a weighed dish after the addition of 5 cubic centimeters of a standard solution of sodium carbonate of such strength as to exactly neutralize the acid present. The residue was then dried to constant weight at 110° C. Control experiments were also made with the acid pepsin solution alone, and the residue obtained from the blank experiment was subtracted from the weight of the residue left by the evaporation of the 50 cubic centimeters of the digested mixture. The quantity thus obtained was multiplied by 5, which gave the amount of matter (peptones and intermediate products together with some salts) dissolved from 20 grams of meat. From their experiments these investigators found that under the conditions mentioned less of the cooked meat was digested than of the raw meat.

Popoff<sup>b</sup> conducted experiments on the rapidity of digestion in which he used, among flesh foods, beef prepared in different ways. His digestive solution was prepared by adding 8 grams of pepsin and 4 grams of hydrochloric acid to 1 liter of water. The quantity of this mixture used for each sample was diluted by an equal volume of water. The beef, which was comparatively lean, was scraped as free as possible of connective tissues and divided into portions of equal weight to be used for analysis and experiment. In the one series of experiments part of the meat had begun to decompose slightly, but it was nevertheless used in order to test its comparative digestibility. The cooking was done in a steam apparatus without the addition of water in the first two series and with 100 cubic centimeters of water

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<sup>a</sup> Amer. Chem. Jour., 6 (1884-85), p. 318.

<sup>b</sup> Ztschr. Physiol. Chem., 14 (1890), p. 524.

in the last two. The artificial digestion was conducted at a temperature of 39° C. and continued five and one-half hours in the first and second series, four hours in the third, and three hours in the fourth. At the end of these periods peptonization was arrested by the addition of 80 milligrams of calcium carbonate. The quantity of protein in the undigested portion was determined and subtracted from that found in a corresponding sample not digested. From his experiments Popoff concluded that beef is more readily digested in the raw than in cooked condition; that cooking decreases its digestibility; that the longer it is cooked the more difficult its digestibility becomes.

Stutzer<sup>a</sup> also made some experiments by the method of artificial digestion which he devised to determine whether raw meat is as rapidly digested as cooked meat. For this purpose he divided a large piece of good lean beef into two parts, one of which he cut into coarse pieces, which he dried at 40° C. and ground fine. The other part he cooked in an ordinary manner, and then cut it up, dried, and ground it in the same way that he did the uncooked part. He treated small portions of each in the same manner with digestive solutions. He used solutions of different strength, but in each case digestion was continued at 38° to 40° C. for thirty minutes. From a comparison of the proportions of the original nitrogenous material that were actually dissolved he drew a conclusion in harmony with that of Popoff's, that the digestibility of the meat was decreased by cooking.

The more specific object of some of the above-mentioned investigations was to determine the total amount of nitrogenous material that would be digested under certain conditions. They do not give much information regarding the ease of digestion. The experiments made by Popoff and Stutzer, however, were made, as explained, to compare the relative ease of digestion of raw and cooked meat; but these give practically no information as to whether differences in methods of cooking the meat have different effects upon the ease of digestion.

#### INVESTIGATIONS HERE REPORTED.

Some knowledge regarding the effects of different methods of cooking upon the ease or rapidity of digestion of meat seemed especially desirable. The investigations undertaken by the authors regarding the various factors that influence the nutritive value of meat seemed to offer very favorable opportunity for a study of this subject. Accordingly, in connection with the experiments on the completeness of digestion reported on preceding pages of this bulletin, attention was devoted to a study of the relative ease of digestion of different kinds and cuts of meat, cooked in different ways.

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<sup>a</sup> Landw. Vers. Stat., 40 (1892), p. 321.

It was, of course, impossible to make such study by observation of the natural process of digestion with the different subjects, and none of the data actually obtained in the natural digestion experiments throw any light upon the ease of digestion of the meats used. It is possible that in time our knowledge of the metabolic products may be such that these will afford some indication of the ease of digestion, but as yet it is entirely inadequate. The only method available, therefore, was that of artificial digestion. The limitations of such experiments in a study of total digestibility have already been pointed out. Similar criticism might also be made of the use of such methods for a study of ease of digestion. It seemed reasonable to believe, however, that the method could be so adapted as to give approximately correct evidence of the rapidity with which protein may be peptonized. Incomplete as such evidence may be, it would seem possible to make it trustworthy so far as it applies, and in the present lack of more definite information it would be of great practical value in dietetics, especially for dyspeptic and other persons who must be relieved to some extent of digestive effort.

In all, 99 artificial digestion experiments were completed as described in detail on the following pages. Of these 7 were of a preliminary nature, made in connection with the study and development of method described below; the other 92 were conducted according to the method finally adopted.

#### DEVELOPMENT OF METHOD.

None of the methods followed in the earlier investigations mentioned was especially adapted, in all particulars, to the purposes of the experiments which it was desired to undertake; nor could the present authors discover any investigations in which the Stutzer method of artificial digestion had been modified in such a way as to show the relative ease or rapidity of digestion of different foods. Attention had to be devoted at first, therefore, to a development of a suitable method of procedure. The various factors that had to be taken into account in order to provide a method by which uniformity of results under identical conditions could be secured are here considered in more or less detail.

*Composition of the digestive solution.*—A few preliminary tests were made, to determine the most suitable composition of digestive solution. In each case 2.5 grams of pepsin were dissolved in 1 liter of hydrochloric acid; but three strengths of acid were used—one of 0.2 per cent, one of 0.33 per cent, and one of 0.2 per cent at the beginning but with subsequent additions of 10 per cent acid until the strength of the acid in the solution was 0.5 per cent. The most uniform and satisfactory results obtained were those with a digestive solution made by adding 2.5 grams of pepsin to 1 liter of 0.33 per

cent hydrochloric acid, and this was adopted as a standard digestive solution for the preliminary investigations. Of this standard solution the same amount, 100 cubic centimeters, was used for each sample.

*Proportion of meat to a given amount of digestive solution.*—The total action of the digestive solution is appreciably affected by the quantity of material to be dissolved. A given amount of the solution will digest a smaller sample more thoroughly than a larger one when the other conditions are the same in both cases. It was not the purpose of these experiments to determine the maximum digestibility of meat under given conditions, but it was believed that the particular purpose of the investigation could be more satisfactorily attained if the size of the sample were such that its retarding influence upon digestion would be minimized. From the results of study of this question it was concluded that from 0.8 to 1.2 grams of dry powdered meat was the most suitable size of sample to be used with 100 cubic centimeters of the standard digestive solution.

This proportion is decidedly smaller than that used by some of the other investigators mentioned above, notably Jessen, and Chittenden and Cummins. It was found, however, that the total digestibility obtained with the smaller sample was in the main larger than those obtained by other investigators, and the results with similar samples were much more concordant.

*Temperature of digestion.*—In so many of the previous investigations the temperature of 38° to 40° C. had been found satisfactory that it was adopted in the present experiments without much preliminary testing.

*Filtering the digested product.*—The effect of the digestive solution upon the meat was determined by comparing the quantity of nitrogen in the material before digestion with that remaining in the undigested residue. Because of the slowness with which the solution filtered, an attempt was made at first to determine the nitrogen in aliquot parts of the filtrate, as was done by Chittenden and Cummins and by Stutzer. The unavoidable evaporation of the solution, the use of large factors to find the total amount digested, and the necessary corrections for nitrogen of pepsin, afforded so much opportunity for error that this method was soon discarded. Efforts were then made to provide some method for more rapid filtration. Qualitative filter paper was tried, but though the solution passed through it rapidly the undigested residue was not all retained. The suction pump with hardened filter paper was inconvenient, as it required too much attention and was about as slow as without the use of the pump. The method that proved most satisfactory, and which was finally adopted, is as follows: Hardened quantitative filter paper, 9 centimeters in diameter, containing 0.1 milligram of nitrogen per paper, was folded in 32 sectors so as to present a corrugated surface and

expose practically all of it to the filtering solution. Such folded filter papers were placed in two funnels, held one above the other, and the flask containing the solution inverted in the top funnel so that the solution would run into the filter automatically. Such an arrangement required very little watching. When the solution had all passed through both papers the residue was washed free from peptones, and both filter papers, with their residues, were put into the Kjeldahl flasks for the nitrogen determination. The tops of the filter papers were cut off, when necessary and practicable.

*Duration of the digestive period.*—Several preliminary experiments were made to determine what length of time the digestion should be continued. Chittenden and Cummins digested their samples for twenty-two hours; but their object was to ascertain total or maximum digestibility. Stutzer, on the other hand, in studying the relative ease of digestion of raw and cooked meat, digested his samples only thirty minutes.

The results obtained in the first of the preliminary tests in the present investigation are reported in Table 26. All the samples used in the tests included in the upper portion of Table 26 were from the same cut of beef round from an animal about 5 years old. Portions of this cut were cooked as follows: In water at 80° to 85° C. for two hours and for five hours; pan broiled, i. e., fried without added fat; and fried in hot lard. Several samples of the meat cooked by each method, and also of the uncooked meat, were digested in the fresh state (i. e., not dried and ground). In each case the sample was treated with 100 cubic centimeters of digestive solution containing 2.5 grams of pepsin solution in 1 liter of 0.33 per cent hydrochloric acid, and the digestion was continued at 38° to 40° C. for twenty-four hours.

In the tests included in the lower part of Table 26 the digestion was conducted in exactly the same way, but the samples, which were all lean beef round, were from different animals. Nos. 1107 and 1108 were parts of the same cut from an animal 6 years old, the former uncooked and the latter cooked in water at 80° to 85° C. for two hours. No. 1116 was from an animal about 5 years old, and was cooked in water for two hours. Nos. 1119 and 1120 were portions of the same cut from an animal 6 years old, the former uncooked and the latter cooked in water two hours. Nos. 1130 and 1131 were portions of the same cut from an animal 4 years old, the former uncooked and the latter cooked in water one hour. No. 1148 was from an animal 2 years old and was cooked in water three hours. In each case the meat was dried and ground fine, and the samples for digestion were weighed from the finely ground substance.

TABLE 26.—*Tests of effect of acid-pepsin solution upon fresh and air-dried samples of raw and cooked beef digested for 24 hours.*

Laboratory No.	Description of samples.	Nitrogen in			Proportion of total nitrogen in digested material.
		Meat.	Undigested portion.	Digested portion.	
<i>Tests with fresh samples.</i>					
1195	Beef round, raw .....	Gram.	Gram.	Gram.	Per cent.
1195	.....do.....	.1067	.0026	.1041	97.56
1195	.....do.....	.0949	.0028	.0921	97.07
1195	.....do.....	.1114	.0032	.1082	97.13
1195	.....do.....	.1310	.0036	.1274	97.25
1195	.....do.....	.1232	.0031	.1201	97.48
1195	.....do.....	.1239	.0032	.1207	97.42
	Average of 6 tests.....	.1152	.0031	.1121	97.31
1199	Round, cooked 2 hours in water at 80° to 85° C.....	Gram.	Gram.	Gram.	Per cent.
1199	.....do.....	.0888	.0023	.0865	97.41
1199	.....do.....	.0852	.0020	.0832	97.65
1199	.....do.....	.1000	.0026	.0974	97.40
1199	.....do.....	.0835	.0021	.0814	97.49
1199	.....do.....	.0909	.0025	.0884	97.25
	Average of 5 tests.....	.0897	.0023	.0874	97.44
1200	Round, cooked 3 hours in water at 80° to 85° C.....	Gram.	Gram.	Gram.	Per cent.
1200	.....do.....	.0953	.0028	.0925	97.06
1200	.....do.....	.0843	.0028	.0815	96.68
1200	.....do.....	.0887	.0026	.0861	97.07
1200	.....do.....	.0908	.0027	.0881	97.03
1200	.....do.....	.0981	.0030	.0951	96.94
1200	.....do.....	.0735	.0022	.0713	97.01
	Average of 6 tests.....	.0885	.0027	.0858	96.95
1197	Round, broiled or "dry fried" .....	Gram.	Gram.	Gram.	Per cent.
1197	.....do.....	.0688	.0025	.0663	96.37
1197	.....do.....	.0867	.0030	.0837	96.54
1197	.....do.....	.0780	.0029	.0751	96.28
1197	.....do.....	.0790	.0026	.0764	96.71
1197	.....do.....	.0728	.0027	.0701	96.29
	Average of 5 tests.....	.0770	.0027	.0743	96.49
1198	Round, fried in hot lard.....	Gram.	Gram.	Gram.	Per cent.
1198	.....do.....	.0765	.0037	.0728	95.29
1198	.....do.....	.0631	.0032	.0599	94.93
1198	.....do.....	.0672	.0033	.0639	95.09
1198	.....do.....	.0803	.0040	.0763	95.02
1198	.....do.....	.0783	.0035	.0748	95.53
1198	.....do.....	.0724	.0036	.0688	95.03
	Average of 6 tests.....	.0730	.0036	.0694	95.07
<i>Tests with air-dried samples.</i>					
1107	Beef round, raw, 1st test.....	Gram.	Gram.	Gram.	Per cent.
1107	Round, raw, 2d test.....	.1450	.0031	.1419	97.86
1107	Round, raw, 3d test.....	.1237	.0024	.1213	98.06
	Average of 3 tests.....	.1325	.0025	.1300	98.11
	Average of 3 tests.....	.1337	.0027	.1310	97.98
1108	Round, boiled 2 hours, 1st test.....	Gram.	Gram.	Gram.	Per cent.
1108	Round, boiled 2 hours, 2d test.....	.1264	.0025	.1239	98.02
	Average of 2 tests.....	.1199	.0030	.1169	97.50
	Average of 2 tests.....	.1231	.0027	.1204	97.87
1116	Round, boiled 2 hours, 1st test.....	Gram.	Gram.	Gram.	Per cent.
1116	Round, boiled 2 hours, 2d test.....	.1203	.0029	.1174	97.59
1116	Round, boiled 2 hours, 3d test.....	.1254	.0029	.1225	97.68
	Average of 3 tests.....	.1432	.0035	.1397	97.56
	Average of 3 tests.....	.1296	.0031	.1265	97.61
1119	Round, raw, 1st test.....	Gram.	Gram.	Gram.	Per cent.
1119	Round, raw, 2d test.....	.1223	.0030	.1193	97.55
1119	Round, raw, 3d test.....	.1294	.0030	.1264	97.68
	Average of 3 tests.....	.1386	.0032	.1354	97.69
	Average of 3 tests.....	.1301	.0031	.1270	97.62
1120	Round, boiled 2 hours, 1st test.....	Gram.	Gram.	Gram.	Per cent.
1120	Round, boiled 2 hours, 2d test.....	.1275	.0030	.1245	97.65
1120	Round, boiled 2 hours, 3d test.....	.1193	.0028	.1165	97.65
	Average of 3 tests.....	.1350	.0031	.1319	97.70
	Average of 3 tests.....	.1273	.0030	.1243	97.64

TABLE 26.—*Tests of effect of acid-pepsin solution upon fresh and air-dried samples of raw and cooked beef digested for 24 hours—Continued.*

Lab- oratory No.	Description of samples.	Nitrogen in—			Proportion of total nitrogen in digested material.
		Meat.	Undi- gested portion.	Digested portion.	
<i>Tests with air-dried samples—Continued.</i>					
1130	Round, raw, 1st test.....	0.1517	0.0044	0.1473	97.10
1130	Round, raw, 2d test.....	.2063	.0046	.2017	97.77
	Average of 2 tests.....	.1790	.0045	.1745	97.49
1131	Round, boiled 2 hours, 1st test.....	.1796	.0043	.1753	97.61
1131	Round, boiled 2 hours, 2d test.....	.1258	.0024	.1234	98.09
1131	Round, boiled 2 hours, 3d test.....	.1178	.0022	.1156	98.13
	Average of 3 tests.....	.1411	.0030	.1381	97.87
1148	Round, boiled 2 hours, 1st test.....	.1211	.0033	.1178	97.28
1148	Round, boiled 2 hours, 2d test.....	.1456	.0047	.1409	96.77
1148	Round, boiled 2 hours, 3d test.....	.1287	.0037	.1250	97.13
	Average of 3 tests.....	.1318	.0039	.1279	97.04
	Average of 8 series of tests.....	.1370	.0032	.1337	97.59

From the results of these tests it seemed quite evident that the nitrogenous material of the meat was rather completely dissolved when the digestion was continued for twenty-four hours. Furthermore, it also appeared that there was no material difference in the thoroughness of digestion whether the meat was uncooked or cooked in water for two or for five hours. This was about equally true whether the fresh or air-dried samples were considered. In the case of the fresh pan broiled and fried meats the digestion was a little less thorough, but the differences were not very large. It seemed apparent from these tests that practically nothing could be learned regarding ease of digestion if the action of the pepsin solution used were allowed to continue twenty-four hours. It would be impossible to make sufficient differentiations when the differences were small.

*Checking the action of the digestive solution.*—Attention was next devoted to a consideration of the question whether differences in the ease of digestion, if there were any, could be determined by continuing the digestion for shorter periods. In order to accomplish this, some means of checking the action of the digestive solution had to be found, because the filtering process is at best slow, requiring twenty-four to twenty-five hours, and would afford opportunity for considerable differences in results if the action of the pepsin were allowed to continue unchecked.

The effect of lowering the temperature of the solution was first tested. Chittenden<sup>a</sup> suggests that a lowering of the temperature below 38° C. causes an immediate effect upon proteolysis. He states

<sup>a</sup> *Digestive Proteolysis*, p. 18.

that "exposure to a low temperature retards proteolytic action doubtless in the same manner that cold checks or retards other chemical changes." In accordance with this idea, experiments were made to determine the action of the pepsin solution at room temperature (22° to 26° C.) and at the temperature of the refrigerator (4° to 5° C.) to learn whether in that way the action of the pepsin could be stopped. The results of these experiments are given in Table 27. The samples used were the same as in the tests given in Table 26, and the other conditions aside from temperature were identical with those of the experiments there reported. The tests were made in duplicate or triplicate in each case.

TABLE 27.—*Tests of effects of low temperature upon the action of the acid-pepsin solution.*

Sample No.	Description of sample.	Digested at 22° to 26° C.				Digested at 4° to 5° C.			
		Nitrogen in—			Proportion of total nitrogen in digested material.	Nitrogen in—			Proportion of total nitrogen in digested material.
		Total sample.	Undigested portion.	Digest-ed por-tion.		Total sample.	Undigested portion.	Digest-ed por-tion.	
1107a	Lean beef round, raw .....	Gram. 0.1219	Gram. 0.0054	Gram. 0.1165	Per ct. 95.57	Gram. 0.1155	Gram. 0.0108	Gram. 0.1047	Per ct. 90.65
1107b	.....do.....	.1206	.0053	.1153	95.61	.1244	.0101	.1133	91.08
1107c	.....do.....	.1203	.0047	.1156	96.09	.1162	.0114	.1048	90.19
	Average.....	.1209	.0051	.1158	95.76	.1187	.0108	.1076	90.64
1116a	Lean beef round, cooked in water 2 hours.....	.1247	.0037	.1210	97.03	.1290	.0098	.1192	92.40
1116b	.....do.....	.1282	.0046	.1236	96.41	.1379	.0126	.1253	90.86
	Average.....	.1264	.0041	.1223	96.72	.1335	.0112	.1223	91.63
1119a	Lean beef round, raw .....	.1182	.0055	.1127	95.35	.1292	.0092	.1200	92.88
1119b	.....do.....	.1196	.0057	.1139	95.23	.1244	.0085	.1159	93.17
1119c	.....do.....	.1281	.0045	.1236	96.49	.....	.....	.....	.....
	Average.....	.1220	.0052	.1167	95.69	.1268	.0089	.1179	93.02

On comparing these results with the ones given in Table 26, it was plain that with the standard digestive solution acting for twenty-four hours the digestion was nearly as thorough when the temperature was 22° to 26° C. as when it was kept at 38° to 40° C., and even at the temperature of 4° to 5° C. it was only a little less complete. It was evident, therefore, that lowering the temperature of the solution would not stop the action of the pepsin sufficiently for the purpose of these experiments.

Attention was then turned to the effect of different substances upon enzymes. Kuhne<sup>a</sup> has pointed out that pepsin is destroyed by digestion with alkaline solutions. Bertels<sup>b</sup> and Dubbs<sup>c</sup> found that large amounts of chloroform decrease the digestive power of pepsin.

<sup>a</sup> Verhandl. Naturhist. Med. Ver. Heidelberg, Feb., 1876.

<sup>b</sup> Arch. Path. Anat. u. Physiol. [Virchow], 130 (1892), p. 497.

<sup>c</sup> Ibid., 134 (1893), p. 519.

Other investigators have found various other substances to have similar effects. In connection with the present investigation, chloroform, mercuric chlorid, and formalin were tested. Chloroform slightly precipitated the peptones or the intermediate products of the action of pepsin upon proteids. Mercuric chlorid also tended to form a slight precipitate. For this reason the use of these two substances was abandoned.

Formalin produced no precipitate, but apparently it did not completely check the action of the pepsin. A series of experiments were made, however, to determine whether it could not be satisfactorily employed for the purposes of these investigations.

Samples of raw and cooked meat were treated with 100 cubic centimeters of pepsin solution containing 10 cubic centimeters of 40 per cent formalin, kept at room temperature for twenty-four hours, then filtered, and the nitrogen determined in the undigested residue. In connection with these tests the same meats were also digested in the same way with 100 cubic centimeters of 0.33 per cent hydrochloric acid without pepsin, to determine how much of the solvent action was due to the acid alone. The data of both these tests are given in Table 28.

TABLE 28.—*Tests of effect of formalin upon the action of the acid-pepsin solution.*

Sample No.	Description of sample.	Digestion with acid-pepsin solution containing formalin.				Digestion with acid alone.			
		Nitrogen in		Proportion of total nitrogen in digested material.	Nitrogen in		Proportion of total nitrogen in digested material.		
		Total sample.	Undigested portion.		Digested portion.	Total sample.	Undigested portion.		
1107a	Lean beef round, raw	Gram. .1185	Gram. .0661	Gram. .0524	Per ct. 44.22	Gram. .1302	Gram. .1002	Gram. .0500	Per ct. 23.04
1107b	do	.1240	.0700	.0540	43.55	.1366	.1041	.0325	23.80
	Average	.1213	.0681	.0532	43.86	.1334	.1022	.0312	23.42
1116a	Lean beef cooked in water	.1453	.0962	.0491	35.79	.1318	.1198	.0120	9.10
1116b	do	.1205	.0784	.0421	34.94	.1299	.1184	.0115	8.85
	Average	.1329	.0873	.0456	34.37	.1308	.1191	.0117	8.98
1119a	Lean beef round, raw	.1144	.0535	.0309	53.23	.1288	.1046	.0242	18.79
1119b	do	.1178	.0625	.0553	46.94	.1152	.0937	.0215	18.66
	Average	.1161	.0580	.0581	50.08	.1220	.0992	.0228	18.73
1120a	Lean beef round, cooked in water	.1129	.0617	.0512	45.35	.1212	.1062	.0150	12.38
1120b	do	.1245	.0694	.0551	44.26	.1147	.1009	.0138	12.03
	Average	.1182	.0655	.0531	44.81	.1180	.1036	.0144	12.20
1130a	Lean beef round, raw	.1449	.0839	.0550	37.96	.1333	.1177	.0156	11.70
1130b	do	.1450	.0908	.0542	37.58	.1348	.1180	.0168	12.46
	Average	.1450	.0874	.0546	37.67	.1340	.1178	.0162	12.08
1131a	Lean beef round, cooked in water	.1202	.0719	.0483	40.48	.1245	.1075	.0170	13.65
1131b	do	.1358	.0820	.0538	39.62	.1228	.1052	.0176	14.33
	Average	.1280	.0769	.0511	39.90	.1236	.1063	.0173	13.99

It was evident from these tests that the acid alone had a very appreciable influence upon the digestion of the meat, but that much more was due to the pepsin, since even in the presence of formalin the complete solution digested on the average nearly three times the amount of protein that was dissolved by the acid alone. From a comparison of these results with those given in Table 27, which were obtained by digesting with the acid-pepsin solution without formalin at room temperature for twenty-four hours, it appeared that the presence of the formalin prevented approximately 55 per cent of the protein from being dissolved.

It seemed probable that the more easily digestible material would be dissolved first, and that if the formalin were added after digestion had continued for some time there would be little, if any, further action of the digestive solution during the time required for filtering. To test this hypothesis two sets of experiments were made. In one set digestion was continued for exactly one hour, then 10 cubic centimeters of formalin were added and the solution filtered as rapidly as possible. In the second set the digestion was conducted in exactly the same way, the formalin was added at the end of the hour, and the solution was then allowed to stand twenty-three hours before being filtered. The undigested residues were washed, and nitrogen determined in them in the same way. The data of the tests are given in Table 29.

TABLE 29.—*Tests of effect of adding formalin after digestion had continued one hour.*

Sample No.	Description of sample.	Digested 1 hour, added formalin, filtered at once.				Digested 1 hour, added formalin, and kept at room temperature 23 hours before filtering.			
		Nitrogen in—			Proportion of total nitrogen in digested material.	Nitrogen in—			Proportion of total nitrogen in digested material.
		Total sample.	Undigested portion.	Digested portion.		Total sample.	Undigested portion.	Digested portion.	
1107a	Lean beef, round, raw . . . . .	Gram.	Gram.	Gram.	Per ct.	Gram.	Gram.	Gram.	Per ct.
1107b	do . . . . .	.1147	.0205	.0942	82.13	.1112	.0243	.0869	78.15
1107c	do . . . . .	.1189	.0194	.0995	83.68	.1084	.0222	.0862	79.52
	Average . . . . .	.1168	.0199	.0968	82.88	.1142	.0237	.0904	79.16
1120a	Lean beef, round, cooked in water . . . . .	Gram.	Gram.	Gram.	Per ct.	Gram.	Gram.	Gram.	Per ct.
1120b	do . . . . .	.1091	.0298	.0793	72.69	.1230	.0438	.0792	64.38
1120c	do . . . . .	.1183	.0312	.0781	73.63	.1186	.0325	.0861	72.60
	Average . . . . .	.1177	.0313	.0864	73.41	.1191	.0385	.0806	67.67
1130a	Lean beef, round, raw . . . . .	Gram.	Gram.	Gram.	Per ct.	Gram.	Gram.	Gram.	Per ct.
1130b	do . . . . .	.1253	.0419	.0834	66.56	.1483	.0565	.0918	61.90
1130c	do . . . . .	.1282	.0437	.0845	65.88	.1200	.0421	.0779	64.91
	Average . . . . .	.1346	.0510	.0836	62.11	.1342	.0493	.0849	63.26

TABLE 29.—*Tests of effect of adding formalin after digestion had continued one hour—Continued.*

Sample No.	Description of sample.	Digested 1 hour, added formalin, filtered at once.				Digested 1 hour, added formalin, and kept at room temperature 23 hours before filtering.			
		Nitrogen in			Proportion of total nitrogen in digested material.	Nitrogen in			Proportion of total nitrogen in digested material.
		Total sample.	Undigested portion.	Digested portion.		Total sample.	Undigested portion.	Digested portion.	
1131a	Lean beef, round, cooked in water.....	Gram. 0.1315	Gram. 0.0392	Gram. 0.0923	Per cent 70.19	Gram. 0.1317	Gram. 0.0472	Gram. 0.0845	Per cent 64.16
1131b	do.....	.1292	.0446	.0846	65.48	.1162	.0312	.0850	73.45
1131e	do.....	.1177	.0379	.0798	67.79	.1550	.0392	.0958	70.96
	Average.....	.1261	.0406	.0856	67.88	.1276	.0392	.0884	69.28
1148a	Lean beef, round, cooked in water.....	.1244	.0700	.0914	75.88	.1247	.0298	.0949	76.40
1148b	do.....	.1207	.0194	.1013	83.93	.1162	.0198	.0964	82.96
1148c	do.....	.1275	.0330	.0945	74.12	.1170	.0218	.0952	81.37
1148d	do.....	.1229	.0306	.0923	75.10	.1196	.0294	.0902	75.42
1148e	do.....	.1286	.0335	.0951	73.95	.1341	.0353	.0988	73.68
1148f	do.....					.1188	.0313	.0875	73.65
	Average.....	.1248	.0293	.0955	76.52	.1217	.0279	.0938	77.07

In some cases the results of these tests were not very satisfactory, but on the whole they seemed to warrant the conclusion that after digestion had continued for an hour or more, formalin could be used quite effectively to check the action of the pepsin solution, so that there would be little or no further digestion during the filtering process.

#### TESTS OF METHOD ADOPTED.

When these facts had been established, a method for studying the relative ease or rapidity of digestion of meat cooked in different ways seemed available, and the following experiments were carried out:

A large piece of lean beef round, from an animal about 5 years old, was divided into five similar portions, one of which (No. 1195) was not cooked, one (No. 1199) was cooked in water at 80° to 85° C. for two hours, one (No. 1200) was cooked in the same manner for five hours, one (No. 1197) was pan broiled, and one (No. 1198) was fried in hot lard. Each portion was then ground as finely as possible in the fresh condition (i. e., without drying) by passing it several times through a meat cutter, and the total nitrogen in a sample of each was determined by the Kjeldahl method.

Several samples of each portion were digested as follows: Each sample (0.8 to 1.2 grams) was placed in a suitable flask, with 100 cubic centimeters of a digestive solution containing 2.5 grams of pepsin in each liter of 0.33 per cent of hydrochloric acid, and the flask was then placed in a water bath and kept at a temperature of 38° to 40° C. for a definite period. During the digestion the solution was

frequently stirred, and the lumps of meat were broken down. At the end of the digestion period 10 cubic centimeters of a 40 per cent solution of formalin was stirred into the digestive solution, and the latter was then filtered. The undigested residue was washed on the filter paper, and then dropped with the paper into a Kjeldahl flask and the nitrogen in it was determined. From this quantity and that of the nitrogen in the sample before digestion, the proportion digested was estimated. A comparison of these results for the samples cooked in different ways shows which was the more easily digested under the given conditions.

Different lengths of digestion period were tried, namely, one, two, six, and twenty-four hours. The results obtained in digesting the samples twenty-four hours are given in Table 26 preceding. Those for the other three periods named are given in Table 30.

TABLE 30.—*Effect of pepsin solution acting upon raw and cooked beef for different lengths of time.*

Sample No.	Period of digestion and description of sample.	Nitrogen—			Proportion of total nitrogen in digested material.
		In total sample.	In undigested portion.	In digested portion.	
<i>Digested for 1 hour.</i>					
1195a	Lean beef round, raw.....	.01959	.0700	.1259	64.27
1195b	.....do.....	.1013	.0397	.0613	60.51
1195c	.....do.....	.1001	.0368	.0633	63.24
1195d	.....do.....	.0875	.0178	.0697	79.66
1195e	.....do.....	.1171	.0426	.0745	63.62
1195f	.....do.....	.1312	.0372	.0940	71.65
Average.....		.1222	.0407	.0815	66.69
1197a	Lean beef round, pan broiled.....	.0806	.0171	.0635	78.78
1197b	.....do.....	.0689	.0160	.0529	76.78
1197c	.....do.....	.0562	.0145	.0517	78.10
1197d	.....do.....	.0646	.0121	.0525	81.27
1197e	.....do.....	.0949	.0201	.0748	78.82
1197f	.....do.....	.0780	.0181	.0599	76.80
Average.....		.0755	.0163	.0592	78.41
1198a	Lean beef round, fried in hot lard.....	.0697	.0244	.0453	64.99
1198b	.....do.....	.0686	.0247	.0439	64.00
1198c	.....do.....	.0712	.0193	.0517	72.61
1198d	.....do.....	.0742	.0255	.0487	65.63
1198e	.....do.....	.0745	.0243	.0502	67.38
1198f	.....do.....	.0727	.0208	.0519	71.39
Average.....		.0718	.0232	.0486	67.69
1199a	Lean beef round, cooked in water 2 hours.....	.1158	.0213	.0945	81.61
1199b	.....do.....	.0956	.0165	.0791	82.74
1199c	.....do.....	.0834	.0108	.0726	87.05
1199d	.....do.....	.0733	.0089	.0644	87.86
1199e	.....do.....	.0778	.0104	.0674	86.63
1199f	.....do.....	.0847	.0076	.0771	91.03
Average.....		.0884	.0126	.0758	85.74
1200a	Lean beef round, cooked in water 5 hours.....	.0660	.0153	.0507	76.82
1200b	.....do.....	.0860	.0204	.0656	76.28
1200c	.....do.....	.0750	.0190	.0560	74.67
1200d	.....do.....	.0924	.0213	.0711	76.95
1200e	.....do.....	.0853	.0201	.0652	76.43
1200f	.....do.....	.0780	.0193	.0587	75.26
Average.....		.0804	.0192	.0612	76.12

TABLE 30.—*Effect of pepsin solution acting upon raw and cooked beef for different lengths of time—Continued.*

Sample No.	Period of digestion and description of sample.	Nitrogen			Proportion of total nitrogen in digested material.
		In total sample.	In undigested portion.	In digested portion.	
<i>Digested for 2 hours.</i>					
1195a	Lean beef round, raw.....	.01342	.00404	.00938	69.90
1195b	.....do.....	.1022	.0175	.0847	82.88
1195c	.....do.....	.0974	.0218	.0756	77.62
1195d	.....do.....	.0855	.0116	.0739	86.43
1195e	.....do.....	.1161	.0254	.0907	78.12
1195f	.....do.....	.1158	.0163	.0995	85.92
	Average.....	.1085	.0222	.0863	79.54
1197a	Lean beef round, pan broiled.....	.0714	.0084	.0630	88.24
1197b	.....do.....	.0647	.0084	.0563	87.02
1197c	.....do.....	.0682	.0081	.0601	88.12
1197d	.....do.....	.0671	.0074	.0597	88.97
1197e	.....do.....	.0670	.0083	.0587	87.61
	Average.....	.0677	.0081	.0596	88.04
1198a	Lean beef round, fried in hot lard.....	.0958	.0190	.0768	80.17
1198b	.....do.....	.0741	.0154	.0587	79.22
1198c	.....do.....	.0680	.0173	.0507	74.56
1198d	.....do.....	.0844	.0180	.0664	78.67
1198e	.....do.....	.0871	.0139	.0732	84.04
1198f	.....do.....	.0757	.0112	.0645	85.20
	Average.....	.0808	.0158	.0650	80.45
1199a	Lean beef round, cooked in water 2 hours.....	.0872	.0065	.0805	92.32
1199b	.....do.....	.0978	.0077	.0901	92.13
1199c	.....do.....	.1067	.0086	.0981	91.94
1199d	.....do.....	.0941	.0062	.0879	93.41
1199e	.....do.....	.0911	.0048	.0863	94.73
1199f	.....do.....	.0788	.0044	.0744	94.42
	Average.....	.0926	.0064	.0862	93.09
1200a	Lean beef round, cooked in water 5 hours.....	.0702	.0152	.0550	78.35
1200b	.....do.....	.0817	.0140	.0667	82.86
1200c	.....do.....	.0749	.0134	.0615	82.11
1200d	.....do.....	.0744	.0132	.0612	82.26
1200e	.....do.....	.0750	.0132	.0618	82.40
1200f	.....do.....	.0898	.0162	.0736	81.96
	Average.....	.0777	.0142	.0635	81.73
<i>Digested for 6 hours.</i>					
1195a	Lean beef round, raw.....	.1044	.0142	.0902	86.40
1195b	.....do.....	.0784	.0060	.0724	92.35
1195c	.....do.....	.0586	.0059	.0527	89.93
1195d	.....do.....	.1110	.0057	.1053	94.86
1195e	.....do.....	.0847	.0105	.0742	87.60
1195f	.....do.....	.1050	.0090	.0968	91.49
	Average.....	.0905	.0086	.0819	90.50
1197a	Lean beef round, pan broiled.....	.0689	.0047	.0642	93.18
1197b	.....do.....	.0764	.0055	.0709	92.80
1197c	.....do.....	.0732	.0059	.0673	91.94
1197d	.....do.....	.0861	.0062	.0799	92.80
1197e	.....do.....	.0673	.0028	.0645	95.84
1197f	.....do.....	.0821	.0073	.0748	91.11
	Average.....	.0757	.0054	.0703	92.87
1198a	Lean beef round, fried in hot lard.....	.0729	.0071	.0658	90.26
1198b	.....do.....	.0796	.0091	.0705	88.57
1198c	.....do.....	.0792	.0062	.0730	92.17
1198d	.....do.....	.0739	.0052	.0687	92.96
1198e	.....do.....	.0620	.0044	.0576	92.90
1198f	.....do.....	.0731	.0070	.0661	90.42
	Average.....	.0734	.0065	.0669	91.14

TABLE 30.—*Effect of pepsin solution acting upon raw and cooked beef for different lengths of time—Continued.*

Sample No.	Period of digestion and description of sample.	Nitrogen—			Proportion of total nitrogen in digested material.
		In total sample.	In undigested portion.	In digested portion.	
<i>Digested for 6 hours—Continued.</i>					
1199a	Lean beef round, cooked in water 2 hours.....	.0825	.0029	.0796	96.48
1199b	.....do.....	.1057	.0047	.1012	95.74
1199c	.....do.....	.0962	.0037	.0925	96.15
1199d	.....do.....	.0988	.0038	.0950	96.15
1199e	.....do.....	.0891	.0028	.0863	96.86
1199f	.....do.....	.0869	.0027	.0842	96.89
	Average.....	.0932	.0034	.0898	96.35
1200a	Lean beef round, cooked in water 5 hours.....	.0660	.0030	.0630	95.45
1200b	.....do.....	.0765	.0029	.0736	96.21
1200c	.....do.....	.0662	.0031	.0631	95.32
1200d	.....do.....	.0725	.0034	.0691	95.31
1200e	.....do.....	.0814	.0045	.0769	94.47
1200f	.....do.....	.0738	.0034	.0704	95.39
	Average.....	.0727	.0034	.0693	95.32

The averages of the results obtained in the individual tests, including those given in Table 26 as well as those in the table above, are summarized in Table 31.

TABLE 31.—*Summary of results of artificial digestion experiments with raw and cooked beef.*

Sample No.	Description of sample.	Coefficients of digestibility of meats treated with pepsin solution for—			
		1 hour.	2 hours.	6 hours.	24 hours.
1195	Lean beef, round, raw.....	66.69	79.54	90.50	97.31
1197	Lean beef, round, pan broiled.....	78.41	88.04	92.87	96.49
1198	Lean beef, round, fried in hot lard.....	67.69	80.45	91.14	95.07
1199	Lean beef cooked in water 2 hours.....	85.74	93.09	96.35	97.44
1200	Lean beef, round, cooked in water 5 hours.....	76.12	81.73	95.32	96.95

No conclusions regarding the relative ease of digestion of the different samples are drawn from the above data, because they are too few. The particular information that was derived from these tests was that the method developed seemed admirably adapted for a study of the question. The variations in results obtained in duplicate tests were in some instances rather wider than is desirable, but it was believed that with more skill in manipulation, and with such refinement in technique as would come with practice, more uniform results could be obtained.

It will be noticed that the above tests were made with meat in the fresh condition, ground as small as possible with a meat cutter or sausage mill; whereas in previous tests the meat had been dried and very finely ground before digestion. A test was made with the uncooked meat used in the above experiment, to determine whether the same results could be obtained with the fresh as with the dried material. Part of the raw meat was dried and ground as usual, and

samples were digested in the same way as the fresh samples were. The averages of the results obtained in the individual tests are compared in Table 32.

TABLE 32. *Comparison of results with fresh and dried samples of meat.*

Sample No.	Description of sample.	Coefficients obtained by digestion for			
		1 hour.	2 hours.	6 hours.	24 hours.
1195	Lean beef, round, raw, fresh substance . . . . .	66.69	79.54	90.50	97.31
1195	Lean beef, round, raw, dried substance . . . . .	65.57	75.29	89.14	97.49

The advantage seemed to be in favor of the digestion of the fresh substance. Accordingly in subsequent experiments this method was followed, in general, in order to avoid the drying and grinding of the material.

#### DETAILS OF EXPERIMENTS ON THE EASE OF DIGESTION OF PROTEIN.

As previously stated, 92 experiments were made with different kinds and cuts of meat cooked in different ways. Of these, 67 were with beef, 5 with mutton, and 20 with pork. In some cases the meats used in these experiments were the same as those in the natural digestion experiments, and in other cases different kinds of meats were used for the artificial digestion tests.

The method employed was that explained on preceding pages, except that the strength of the acid-pepsin solution was altered. In all the experiments hereafter reported the digestive solution contained 1.25 grams of pepsin, instead of 2.5 grams, in each liter of 0.33 per cent hydrochloric acid. In all other respects the method was as outlined above (p. 72).

In several cases a large piece of some particular "cut" of meat was divided into several similar portions, one of which was not cooked and the others were cooked in different ways. In such cases there is opportunity for comparing results with raw and cooked meats that before cooking were as nearly alike as possible. In other instances similar cuts of meat from different animals were used, some of which were not cooked, while the remainder were all cooked in the same way.

Several of the experiments were made with different "cuts" of meat from the same animal, all cooked in the same way, to determine whether there is any difference in the ease of digestion of meat from different parts of the same carcass.

Both fat meats and lean meats were used, to ascertain how they compare in respect to ease of digestion. In order that the relative fatness of the meats might be definitely known samples were analyzed in the usual way. The data regarding the composition of these samples are given in Table 33.

TABLE 33.—Composition of meats used in artificial digestion experiments here reported.

Laboratory No.	Kind of meat.	Used in experiment No.	Water.	Protein (N×6.25).	Fat.	Ash.
			Percent.	Percent.	Percent.	Percent.
1390	Beef round, cooked in water	43	61.71	36.20	1.99	0.93
1395	do	48	59.52	34.20	6.19	1.03
1403	do	55	53.12	30.08	16.34	.81
1465	do	70	53.66	30.83	16.05	.93
1634	do	94	61.79	33.84	3.27	1.04
1635	do	95	62.78	33.75	2.65	1.01
1388	Beef round, raw	41	76.84	20.75	1.78	1.09
1393	do	46	75.64	21.17	2.42	1.16
1389	Beef round, pan broiled	42	68.86	28.18	2.15	1.32
1394	do	47	59.02	34.27	6.42	1.50
1391	Beef round, fried in lard	44	60.54	32.54	5.95	1.40
1396	do	49	48.67	41.09	9.77	1.62
1392	Beef round, roasted	45	57.92	35.66	6.05	1.37
1397	do	50	55.87	36.34	7.60	1.33
1399	Beef ribs, cooked in water	51	51.16	22.78	26.20	.82
1461	do	66	49.43	18.07	32.53	.67
1520	Beef ribs, raw	81	49.89	16.11	33.77	.72
1521	do	82	48.16	14.35	36.96	.69
1522	do	83	35.77	10.56	53.29	.52
1535	do	84	46.09	13.61	39.58	.67
1541	do	85	48.54	14.82	35.90	.73
1611	do	94	51.46	14.81	33.62	.72
1612	do	95	46.43	12.60	40.62	.61
1613	do	96	60.00	17.82	21.78	.86
1537	Beef ribs, roasted	81	47.51	20.16	32.08	.91
1536	do	82	40.49	19.73	39.60	.91
1538	do	83	32.94	15.78	51.32	.72
1539	do	84	62.89	17.89	18.34	.80
1540	do	85	56.20	18.95	24.33	.89
1587	do	91	35.12	19.50	44.92	.79
1588	do	91	49.63	21.95	28.26	.95
1589	do	92	28.02	21.94	49.60	.87
1590	do	92	42.45	20.97	36.85	.82
1591	do	93	54.53	23.55	21.61	.95
1595	do	93	49.88	20.56	28.06	2.37
1615	do	94	45.74	18.22	35.49	.92
1614	do	95	33.30	16.34	50.04	.74
1616	do	96	54.83	19.26	25.16	.97
1617	do	97	43.51	23.63	30.67	2.34
1561	do	97	55.11	24.64	18.21	2.55
1525	do	97	44.43	20.04	34.09	1.93
1400	Beef leg, cooked in water	52	60.14	26.30	13.60	.74
1462	do	67	65.00	24.88	10.07	.89
1401	Beef neck, cooked in water	53	62.96	22.23	14.58	.91
1463	do	68	58.19	18.15	23.59	.70
1402	Beef flank, cooked in water	54	51.80	20.59	27.62	.71
1464	do	69	51.29	19.16	29.67	.63
1424	Mutton, shoulder, cooked in water	56	42.82	19.70	37.05	.77
1425	Mutton, flank, cooked in water	57	40.82	16.85	42.44	.56
1426	Mutton, leg, cooked in water	58	61.09	22.15	16.60	.99
1427	Mutton, loin	59	38.27	16.17	45.42	.55
1428	Mutton, ribs	60	47.77	18.28	33.69	.67
1482	Pork, fresh ham, raw	71	61.61	15.76	21.85	.83
1485	do	72	54.48	13.64	31.61	.66
1487	do	73	49.58	13.90	35.94	.72
1488	do	74	52.54	14.13	33.10	.74
1490	do	75	51.07	14.50	33.82	.73
1492	do	76	54.80	14.00	30.58	.70
1505	do	77	52.73	13.96	33.07	.78
1507	do	78	35.04	14.76	49.49	.82
1510	do	79	55.88	14.95	29.05	.80
1515	do	80	63.77	16.35	19.48	.93
1542	do	86	58.45	16.10	24.84	.85
1543	do	87	57.76	15.50	26.50	.77
1544	do	88	58.29	17.41	24.01	.82
1432	Pork, fresh ham, cooked in water	63	50.49	17.32	31.69	.66
1483	Pork, fresh ham, roasted	71	53.37	23.00	23.38	1.02
1484	do	72	50.45	16.76	31.92	.79
1486	do	73	51.46	21.78	26.51	.88
1489	do	74	48.17	21.42	29.80	.91
1491	do	75	41.20	29.15	29.63	.99
1493	do	76	51.61	18.99	28.78	.87
1504	do	77	51.22	18.95	29.39	.96
1506	do	78	49.38	23.63	26.36	1.08
1511	do	79	55.13	23.44	21.20	1.09
1514	do	80	54.36	23.52	21.82	.88
1545	do	86	53.62	24.77	21.04	1.00
1558	do	87	56.05	26.52	17.09	1.08
1559	do	88	59.12	23.47	17.36	1.02
1573	do	89	53.57	26.40	19.73	1.01

TABLE 33.—*Composition of meats used in artificial digestion experiments here reported—Continued.*

Laboratory No.	Kind of meat.	Used in experiment No.—	Water.	Protein (N×6.25).	Fat.	Ash.
					Per cent.	Per cent.
1574	Pork, fresh ham, roasted.....	89	55.43	24.52	19.44	1.05
1575	.....do.....	90	51.40	25.88	22.46	.99
1580	.....do.....	90	61.71	19.33	18.27	.74
1430	Pork, belly, cooked in water.....	61	41.32	15.52	42.95	.52
1431	Pork, middle cut, cooked in water.....	62	44.61	17.22	37.82	.53
1433	Pork, shoulder, cooked in water.....	64	60.68	21.59	17.31	.81
1434	Pork, back, cooked in water.....	65	52.96	21.14	25.47	.82

### EXPERIMENTS WITH BEEF.

A description of the kinds and cuts of beef and the methods of cooking is here given.

Experiments Nos. 7 to 11 were made with a piece of beef round, from an animal about  $2\frac{1}{2}$  years old, which was divided into five similar portions. No. 1202 was not cooked, No. 1203 was pan broiled, No. 1204 was fried in hot lard, No. 1205 was cooked in water at  $80^{\circ}$  to  $85^{\circ}$  for two hours, and No. 1206 was cooked in the same manner for five hours.

Experiments Nos. 12 to 16 were made with a piece of beef round, from an animal about 3 years old, which was divided into five similar portions. No. 1210 was not cooked, No. 1215 was pan broiled, No. 1219 was fried in lard, No. 1211 was cooked in water at  $80^{\circ}$  to  $85^{\circ}$  for two hours, and No. 1210 was cooked in the same manner for five hours.

Experiments Nos. 17 to 21 were made with a piece of beef round, from an animal about 3 years old, which was divided into five similar portions. No. 1235 was not cooked, No. 1238 was pan broiled, No. 1241 was fried in hot lard, No. 1242 was cooked in water at  $80^{\circ}$  to  $85^{\circ}$  for one hour, and No. 1243 was similarly cooked for five hours.

Experiment No. 22 was made with a piece of very fat beef sirloin, No. 1279, from an animal about  $2\frac{3}{4}$  years old. The meat was broiled in a gas oven until somewhat underdone.

Experiment No. 23 was made with a piece of very fat beef sirloin, No. 1280, from an animal about  $1\frac{3}{4}$  years old. The meat was broiled in a gas oven until well done.

Experiment No. 24 was made with a piece of very fat beef sirloin, No. 1281, from an animal about  $2\frac{1}{2}$  years old. It was broiled in a gas oven until somewhat underdone.

Experiment No. 25 was made with a piece of very fat beef sirloin, No. 1282, from an animal about  $2\frac{1}{2}$  years old. The meat was broiled in a gas oven until somewhat underdone.

Experiment No. 26 was made with a piece of very fat beef sirloin, No. 1283, from an animal about  $2\frac{1}{2}$  years old. The meat was broiled in a gas oven until somewhat underdone.

Experiments Nos. 27 and 28 were made with a piece of very fat beef shoulder from an animal about  $2\frac{1}{2}$  years old. The meat was obtained fifteen days after the animal was slaughtered. The piece was cut into two portions, one of which (No. 1300) was not cooked and the other (No. 1287) was cooked in water at  $80^{\circ}$  to  $85^{\circ}$  for two hours.

Experiment No. 29 was made with a piece of very fat beef sirloin, No. 1302, from an animal about 2 years old. The meat was obtained eighteen days after slaughtering and was not cooked.

Experiment No. 30 was made with a piece of very fat beef sirloin, No. 1303, from an animal about 3 years old. The meat was obtained eighteen days after slaughtering and was not cooked.

Experiment No. 31 was made with a piece of very fat beef sirloin, No. 1305, from an animal about 2 years old. The meat was obtained eighteen days after slaughtering and was not cooked.

Experiment No. 32 was made with a piece of very fat beef sirloin, No. 1306, from an animal about 3 years old. The meat was obtained eighteen days after slaughtering and was broiled in a gas oven.

Experiment No. 33 was made with a piece of very fat beef sirloin, No. 1307, from an animal about 3 years old. The meat was obtained eighteen days after slaughtering and was broiled in a gas oven.

Experiment No. 34 was made with a piece of very fat beef sirloin, No. 1309, from an animal about 2 years old. The meat was obtained twenty-one days after slaughtering and was broiled in a gas oven. The samples were digested nine days after the meat was cooked.

Experiments Nos. 35 and 36 were made with a piece of lean beef round from an animal about 3 years old. One portion of the cut, No. 1314, was not cooked; the other portion, No. 1313, was pan broiled until well done.

Experiments Nos. 37 and 38 were made with a piece of lean beef round from an animal about 3 years old. One portion of the cut, No. 1331, was not cooked; the other portion, No. 1330, was fried in hot lard.

Experiments Nos. 39 and 40 were made with a piece of lean beef round from an animal about 2 years old. One portion of the cut, No. 1348, was not cooked; the other portion, No. 1347, was roasted in a gas oven until well done.

Experiments Nos. 41 to 45 were made with a piece of lean beef round, from an animal about  $2\frac{1}{2}$  years old, which was divided into five portions. No. 1388 was not cooked, No. 1389 was pan broiled until well done, and No. 1390 was kept in boiling water for ten minutes and the temperature of the water was then reduced to  $85^{\circ}$  and cooking was continued for two hours at  $80^{\circ}$  to  $85^{\circ}$ . The meat was well done. No. 1391 was fried in hot lard until well done, No. 1392 was roasted in a gas oven.

Experiments Nos. 46 to 50 were made with a piece of lean beef round, from an animal about 3 years old, which was divided into five portions. No. 1393 was not cooked, No. 1394 was pan broiled until well done, No. 1395 was kept in boiling water for ten minutes then cooked for two hours in water at  $80^{\circ}$  to  $85^{\circ}$ , No. 1396 was fried in hot lard until well done, and No. 1397 was roasted in a gas oven.

Experiments Nos. 51 to 55 were made with different cuts of beef from the same animal, which was about 3 years old at the time of slaughtering. No. 1399 was a very fat first cut of ribs, known locally as "rib roast;" No. 1400 was a moderately fat leg piece, known locally as "soup bone;" No. 1401 was a second cut of the neck, moderately fat, known as a "boiling piece;" No. 1402 was a very fat piece of the flank bone, known locally as the "flank boiling piece;" No. 1403 was a rather fat piece of beef round. In each case the meat was cooked by placing it in boiling water, the temperature of which was maintained at  $100^{\circ}$  for ten minutes, then reduced to  $85^{\circ}$  and kept at  $80^{\circ}$  to  $85^{\circ}$  for two hours.

Experiments Nos. 66 to 70 were made with different cuts of beef from the same animal, which was about 2 years old at the time of slaughtering. No. 1461 was a first cut of the ribs, No. 1462 was a leg piece, No. 1463 was a second cut of the neck, No. 1464 was a flank piece, and No. 1465 was a piece of the round. Each cut was cooked in water which was kept boiling for ten minutes and then at  $80^{\circ}$  to  $85^{\circ}$  for two hours.

Experiment No. 81 was made with beef ribs. One portion (1520) was uncooked and the other portion (1537) was roasted.

Experiment No. 82 was made with beef ribs. One portion (1521) was uncooked and the other portion (1536) was roasted.

Experiment No. 83 was made with beef ribs. One portion (1522) was not cooked and the other portion (1538) was roasted.

Experiment No. 84 was made with beef ribs. One portion (1535) was uncooked and the other portion (1539) was roasted.

Experiment No. 85 was made with beef ribs. One portion (1541) was uncooked and the other (1540) was roasted.

Experiment No. 91 was made with two pieces (1587 and 1588) of roasted beef ribs, very fat.

Experiment No. 92 was made with two pieces (1589 and 1590) of roasted beef ribs, very fat.

Experiment No. 93 was made with two pieces (1591 and 1595) of roasted beef ribs, very fat.

Experiment No. 94 was made with a cut of beef ribs, one portion of which (1611) was uncooked and the other portion (1615) was roasted.

Experiment No. 95 was made with a cut of beef ribs, one portion of which (1612) was uncooked and the other portion (1614) was roasted.

Experiment No. 96 was made with a cut of beef ribs, one portion of which (1613) was uncooked and the other portion (1616) was roasted.

Experiment No. 97 was made with three cuts (1617, 1561, and 1525) of beef ribs roasted.

Experiment No. 98 was made with two similar portions of the same piece of beef round cooked in water that was kept boiling for ten minutes and then at 80° to 85° C. for two hours. One portion (1634) was ground twice in a sausage mill and the other portion (1635) was cut into quarter-inch cubes. The purpose of this experiment was to afford some indication regarding effect of thorough mastication upon the ease of digestion.

The data regarding the artificial digestion of the protein of the above samples are given in Table 35. In a very few cases the figures there given represent the data from individual tests, but in the large majority of cases they are the averages for several tests with the same sample, the number included in the average ranging from 2 to 5, as shown in one of the columns. For example, in the case of the first item in the table, with sample No. 1202 digested for one hour, four tests, *a*, *b*, *c*, and *d*, were made, the data of which are given in Table 34.

TABLE 34.—*Results of individual tests on digestion of raw beef round.*

Sample No.	Nitrogen in—			Proportion of total nitrogen in digested material.
	Total sample.	Undigested portion.	Digested portion.	
1202 <i>a</i> .....	Gram. 0.0715	Gram. .0045	Gram. .0670	94
1202 <i>b</i> .....	.0730	.0045	.0685	94
1202 <i>c</i> .....	.1081	.0103	.0978	90
1202 <i>d</i> .....	.0728	.0058	.0670	92
Average.....	.0814	.0063	.0751	92

The average of the quantities of nitrogen in the four portions of the sample that were weighed for digestion was 0.0814 gram; that in the undigested residue, 0.0063 gram, and in the digested portion, 0.0751 gram. According to these figures 92 per cent, on the average, of the nitrogen of the meat was present in the protein that was digested. Among the individual tests the proportion ranged from 90 to 94 per

cent. These latter figures are given in the last two columns of Table 35 to show the variations in results of the individual tests from which the average figures were derived.

TABLE 35.—*Results obtained in artificial digestion of samples of different cuts of beef, raw and cooked in different ways.*

Laboratory No.	Description of sample.	Number of tests in average.	Nitrogen in		Proportion of total nitrogen in digested portion.				
			Meat.	Undigested portion.	Digested portion.	Average.	Minimum.		
<i>Digested 1 hour.</i>									
Experiments Nos. 7-11:									
	Beef round—		Gram.	Gram.	Gram.	Per cent.	Per cent.		
1202	Raw.....	4	.0814	.0063	.0751	92.26	90.44		
1203	Pan broiled.....	3	.0720	.0178	.0542	75.28	74.72		
1204	Fried in hot lard.....	3	.0757	.0205	.0552	72.92	72.57		
1205	Cooked in water 2 hours.....	4	.0617	.0305	.0312	50.57	48.13		
1206	Cooked in water 5 hours.....	4	.0767	.0292	.0475	61.93	58.65		
Experiments Nos. 12-16:									
	Beef round, lean—		Gram.	Gram.	Gram.	Per cent.	Per cent.		
1210	Raw.....	4	.0911	.0127	.0784	86.06	85.57		
1211	Cooked in water 2 hours.....	4	.0994	.0155	.0829	84.41	78.76		
1212	Cooked in water 5 hours.....	4	.0943	.0112	.0831	88.12	85.47		
1215	Pan broiled.....	4	.0644	.0144	.0500	77.64	75.93		
1219	Fried in hot lard.....	4	.0947	.0237	.0710	74.97	72.28		
Experiments Nos. 17-21:									
	Beef round, lean—		Gram.	Gram.	Gram.	Per cent.	Per cent.		
1235	Raw.....	5	.0950	.0100	.0850	89.47	87.52		
1238	Pan broiled.....	4	.0546	.0090	.0456	83.52	80.48		
1241	Fried in hot lard.....	4	.0993	.0218	.0775	78.05	75.75		
1242	Cooked in water 1 hour.....	4	.0933	.0145	.0788	84.46	81.85		
1243	Cooked in water 5 hours.....	3	.0748	.0136	.0612	81.82	79.28		
Experiments Nos. 22-26:									
	Beef sirloin, very fat, broiled, underdone.....		Gram.	Gram.	Gram.	Per cent.	Per cent.		
1279	Beef sirloin, very fat, broiled, underdone.....	3	.0490	.0078	.0412	84.08	82.93		
1280	Beef sirloin, very fat, broiled, well done.....	3	.0591	.0139	.0452	76.48	68.09		
1281	Beef sirloin, very fat, broiled, underdone.....	3	.0412	.0109	.0303	73.54	72.28		
1282	do.....	3	.0498	.0092	.0406	81.53	81.18		
1283	do.....	3	.0980	.0225	.0755	77.04	76.19		
Average of 5.....									
			Gram.	Gram.	Gram.	Per cent.	Per cent.		
1287	Beef shoulder, very fat, cooked in water 2 hours.....	3	.0890	.0187	.0703	78.99	78.37		
1300	Beef shoulder, moderately fat, raw.....	4	.0970	.0158	.0812	83.71	82.30		
Experiments Nos. 29-31:									
	Beef sirloin, very fat, raw.....		Gram.	Gram.	Gram.	Per cent.	Per cent.		
1302	Beef sirloin, very fat, raw.....	3	.0757	.0159	.0598	79.00	77.58		
1303	Do.....	3	.0476	.0095	.0381	80.04	78.72		
1305	Do.....	3	.0612	.0108	.0504	82.35	82.16		
Average of 3.....									
			Gram.	Gram.	Gram.	Per cent.	Per cent.		
1306	Beef sirloin, very fat, broiled.....	3	.0663	.0135	.0528	79.64	78.22		
1307	Do.....	3	.0918	.0186	.0732	79.74	78.24		
1309	Do.....	4	.0877	.0146	.0731	83.35	82.38		
Average of 3.....									
			Gram.	Gram.	Gram.	Per cent.	Per cent.		
1314	Beef round, lean, raw.....	3	.1079	.0125	.0954	88.42	87.10		
1313	Beef round, lean, pan broiled, well done.....	3	.0827	.0163	.0664	80.29	78.73		
Experiments Nos. 37-38:									
	Beef round, lean, raw.....		Gram.	Gram.	Gram.	Per cent.	Per cent.		
1331	Beef round, lean, raw.....	3	.0873	.0142	.0731	83.73	83.10		
1330	Beef round, lean, fried in hot lard, well done.....	3	.1030	.0221	.0809	78.54	77.32		
Experiments Nos. 39-40:									
	Beef round, lean, raw.....		Gram.	Gram.	Gram.	Per cent.	Per cent.		
1348	Beef round, lean, raw.....	3	.0951	.0149	.0802	84.33	82.10		
1347	Beef round, lean, roasted, well done	3	.1109	.0133	.0976	88.01	87.53		

TABLE 35.—*Results obtained in artificial digestion of samples of different cuts of beef, raw and cooked in different ways—Continued.*

Laboratory No.	Description of sample.	Number of tests in average.	Nitrogen in			Proportion of total nitrogen in digested portion.				
			Meat.	Undigested portion.	Digested portion.	Average.	Minimum.	Maximum.		
<i>Digested 1 hour—Continued.</i>										
Experiments Nos. 41–45:										
	Beef round, lean		Gram.	Gram.	Gram.	Per ct.	Per ct.	Per ct.		
1388	Raw.....	4	.0913	.0098	.0815	89.27	88.47	90.31		
1389	Pan broiled.....	3	.0897	.0134	.0763	85.06	83.52	86.60		
1390	Cooked in water 2 hours, well done.....	3	.0930	.0179	.0751	80.75	78.44	81.89		
1391	Fried in hot lard, well done.....	3	.0738	.0178	.0560	75.88	75.06	77.05		
1392	Roasted, well done.....	4	.0932	.0161	.0771	82.73	81.90	84.90		
Experiments Nos. 46–50:										
	Beef round, lean		Gram.	Gram.	Gram.	Per ct.	Per ct.	Per ct.		
1393	Raw.....	4	.0872	.0148	.0724	83.03	81.78	84.72		
1394	Pan broiled.....	3	.0827	.0187	.0640	77.39	76.36	78.34		
1395	Cooked in water 2 hours.....	4	.0896	.0249	.0647	72.21	71.12	73.76		
1396	Fried in hot lard.....	3	.1031	.0240	.0791	76.72	76.47	77.35		
1397	Roasted.....	4	.0962	.0138	.0824	85.65	84.91	86.17		
Experiments Nos. 51–55:										
	Beef, different cuts, all cooked in water 2 hours—		Gram.	Gram.	Gram.	Per ct.	Per ct.	Per ct.		
1399	First cut ribs, very fat.....	3	.0722	.0161	.0561	77.70	77.27	78.61		
1400	Leg bone, moderately fat.....	3	.0750	.0246	.0504	67.20	66.58	67.64		
1401	Second cut neck, moderately fat.....	3	.0684	.0172	.0512	74.85	73.59	75.84		
1402	Flank, very fat.....	3	.0670	.0222	.0448	66.87	64.53	68.74		
1403	Round, rather fat.....	3	.0942	.0186	.0757	80.36	78.78	81.07		
Experiments Nos. 66–70:										
	Beef, different cuts, all cooked in water 2 hours—		Gram.	Gram.	Gram.	Per ct.	Per ct.	Per ct.		
1461	First cut ribs, underdone.....	1	.0608	.0132	.0476	78.29	78.29	78.55		
1462	Leg bone.....	2	.0730	.0157	.0573	78.49	78.28	78.55		
1463	Second cut, neck.....	1	.0680	.0201	.0479	70.44	70.44	70.44		
1464	Flank, well done.....	4	.0560	.0180	.0380	67.86	66.53	69.34		
1465	Round, well done.....	3	.1035	.0178	.0857	82.80	82.25	83.68		
<i>Digested 2 hours.</i>										
Experiments Nos. 7–11:										
	Beef round—		Gram.	Gram.	Gram.	Per ct.	Per ct.	Per ct.		
1202	Raw.....	4	.0887	.0052	.0835	94.14	93.83	94.50		
1203	Pan broiled.....	4	.0770	.0135	.0935	82.47	81.27	85.08		
1204	Fried in hot lard.....	4	.0725	.0097	.0628	86.62	85.93	87.27		
1205	Cooked in water 2 hours.....	4	.0609	.0186	.0513	73.39	70.20	75.54		
1206	Cooked in water 5 hours.....	3	.0660	.0167	.0493	74.70	73.43	75.69		
Experiments Nos. 12–16:										
	Beef round, lean—		Gram.	Gram.	Gram.	Per ct.	Per ct.	Per ct.		
1210	Raw.....	4	.0848	.0076	.0772	91.04	90.83	91.29		
1211	Cooked in water 2 hours.....	4	.1083	.0084	.0999	92.24	91.89	92.93		
1212	Cooked in water 5 hours.....	3	.0851	.0077	.0774	90.95	88.47	93.54		
1215	Pan broiled.....	4	.0626	.0079	.0547	87.38	86.10	88.95		
1219	Fried in hot lard.....	4	.0982	.0177	.0805	81.98	78.14	84.03		
Experiments Nos. 17–21:										
	Beef round, lean		Gram.	Gram.	Gram.	Per ct.	Per ct.	Per ct.		
1235	Raw.....	3	.0970	.0083	.0887	91.44	91.11	91.91		
1238	Pan broiled.....	4	.0588	.0056	.0532	90.48	85.94	92.98		
1241	Fried in hot lard.....	4	.0803	.0076	.0727	90.54	89.21	92.06		
1242	Cooked in water 1 hour.....	4	.1069	.0085	.0984	92.05	89.00	95.70		
1243	Cooked in water 5 hours.....	4	.0988	.0098	.0890	90.08	85.77	93.10		
Experiments Nos. 22–26:										
	Beef sirloin, very fat, broiled, underdone.....	3	.0517	.0072	.0445	86.07	85.81	86.31		
1280	Beef sirloin, very fat, broiled, well done.....	3	.0630	.0095	.0535	84.92	83.49	86.57		
1281	Beef sirloin, very fat, broiled, underdone.....	3	.0604	.0118	.0486	80.46	79.70	81.95		
1282	Do.....	3	.0488	.0061	.0427	87.50	86.24	88.02		
1283	Do.....	3	.1123	.0198	.0925	82.37	80.31	84.40		
	Average of 5.....		.0672	.0109	.0564	84.26	.....	.....		
Experiments Nos. 27–28:										
	Beef shoulder, very fat, cooked in water 2 hours.....	3	.0802	.0123	.0679	84.66	83.18	85.73		
1300	Beef shoulder, moderately fat, raw.....	3	.1015	.0141	.0874	86.14	85.21	87.73		

TABLE 35.—*Results obtained in artificial digestion of samples of different cuts of beef, raw and cooked in different ways—Continued.*

Laboratory No.	Description of sample.	Number of tests in average.	Nitrogen in—			Proportion of total nitrogen in digested portion.		
			Meat.	Undigested portion.	Digested portion.	Average.	Minimum.	Maximum.
<i>Digested 2 hours—Continued.</i>								
1302	Experiments Nos. 29-31: Beef sirloin, very fat, raw.....	2	Gram.	Gram.	Gram.	Per cent.	Per cent.	Per cent.
1303	Do.....	3	.0706	.0085	.0621	87.96	87.70	88.21
1305	Do.....	3	.0517	.0067	.0450	87.04	86.06	88.28
	Average of 3.....	3	.0645	.0078	.0567	87.91	86.59	89.13
1306	Experiments Nos. 32-34: Beef sirloin, very fat, broiled.....	4	.0768	.0098	.0670	87.24	86.59	88.26
1307	Do.....	3	.0806	.0111	.0695	86.23	86.12	86.50
1309	Do.....	3	.0936	.0127	.0809	86.43	85.99	87.16
	Average of 3.....	3	.0837	.0112	.0725	86.63	.....	.....
1314	Experiments Nos. 35-36: Beef round, lean, raw.....	2	.0991	.0081	.0910	91.83	91.67	91.89
1313	Beef round, lean, pan broiled, well done.....	3	.0919	.0119	.0850	87.72	86.81	88.86
1331	Experiments Nos. 37-38: Beef round, lean, raw.....	3	.1060	.0126	.0934	88.11	87.62	88.77
1330	Beef round, lean, fried in hot lard, well done.....	3	.1094	.0199	.0895	81.81	80.30	82.74
1348	Experiments Nos. 39-40: Beef round, lean, raw.....	4	.0888	.0093	.0795	89.53	88.54	90.05
1347	Beef round, lean, roasted, well done.....	4	.0940	.0097	.0843	89.68	89.08	90.60
1388	Experiments Nos. 41-45: Beef round, lean—							
1389	Raw.....	4	.0761	.0085	.0676	88.83	88.22	89.90
1390	Pan broiled.....	3	.0895	.0074	.0821	91.73	91.16	92.79
1390	Cooked in water 2 hours, well done.....	3	.0925	.0126	.0799	86.38	84.17	88.48
1391	Fried in hot lard, well done.....	3	.0890	.0110	.0780	87.64	86.24	88.87
1392	Roasted, well done.....	4	.0863	.0087	.0776	89.92	89.09	90.42
1393	Experiments Nos. 46-50: Beef round, lean—							
1394	Raw.....	2	.1049	.0165	.0884	84.27	83.85	84.67
1395	Pan broiled.....	3	.0771	.0123	.0648	84.05	83.69	84.74
1396	Cooked in water 2 hours.....	2	.1038	.0164	.0874	84.20	84.03	84.25
1397	Fried in hot lard.....	1	.1124	.0237	.0887	78.91	.....	.....
	Roasted.....	3	.0949	.0078	.0871	91.78	91.67	91.81
1399	Experiments Nos. 51-55: Beef, different cuts, all cooked in water 2 hours—							
1400	First cut ribs, very fat.....	3	.0758	.0101	.0657	86.68	85.57	87.40
1401	Leg bone, moderately fat.....	3	.0790	.0176	.0614	77.72	75.33	80.18
1402	Second cut, neck, moderately fat.....	3	.0686	.0140	.0546	79.59	78.51	80.71
1403	Flank, very fat.....	3	.0774	.0207	.0567	73.26	72.71	73.71
	Round, rather fat.....	3	.0812	.0087	.0725	89.29	88.57	90.01
1462	Experiments Nos. 66-70: Beef, different cuts, all cooked in water 2 hours—							
1463	Leg bone.....	2	.0763	.0112	.0651	85.32	85.18	85.45
1464	Second cut, neck.....	4	.0517	.0133	.0384	74.28	69.41	77.72
1465	Flank, well done.....	4	.0617	.0158	.0459	74.39	70.52	78.37
	Round, well done.....	3	.1046	.0130	.0916	87.57	86.84	88.58
1520	Experiment No. 81: Beef ribs, very fat, raw.....	3	.0533	.0049	.0484	90.81	87.10	93.71
1537	Beef ribs, very fat, roasted.....	3	.0629	.0083	.0646	86.80	85.61	87.95
1521	Experiment No. 82: Beef ribs, very fat, raw.....	4	.0519	.0072	.0447	86.13	82.53	90.22
1536	Beef ribs, very fat, roasted.....	3	.0618	.0092	.0526	85.11	84.82	85.51
1522	Experiment No. 83: Beef ribs, very fat, raw.....	3	.0352	.0045	.0307	87.22	84.55	89.49
1538	Beef ribs, very fat, roasted.....	3	.0532	.0084	.0448	84.21	83.15	85.46
1535	Experiment No. 84: Beef ribs, very fat, raw.....	2	.0493	.0047	.0446	90.47	89.44	91.53
1539	Beef ribs, very fat, roasted.....	3	.0605	.0108	.0497	82.15	79.97	84.45
1541	Experiment No. 85: Beef ribs, very fat, raw.....	3	.0470	.0075	.0395	84.04	83.19	84.46
1540	Beef ribs, very fat, roasted.....	3	.0640	.0107	.0533	83.28	82.37	84.53

TABLE 35.—*Results obtained in artificial digestion of samples of different cuts of beef, raw and cooked in different ways—Continued.*

Laboratory No.	Description of sample.	Number of tests in average.	Nitrogen in—			Proportion of total nitrogen in digested portion.		
			Meat.	Undigested portion.	Digested portion.	Average.	Minimum.	Maximum.
<i>Digested 2 hours—Continued.</i>								
1587	Experiment No. 91: Beef ribs, very fat, roasted.....	4	.0638	.0099	.0539	84.48	83.51	84.95
1588	Do .....	2	.0614	.0125	.0489	79.64	79.41	79.93
	Average of 2.....		.0626	.0112	.0514	82.06	.....	.....
1589	Experiment No. 92: Beef ribs, very fat, roasted.....	2	.0736	.0150	.0586	79.62	79.52	79.77
1590	Do .....	3	.0536	.0095	.0441	82.27	81.53	83.37
	Average of 2.....		.0636	.0123	.0513	80.95	.....	.....
1591	Experiment No. 93: Beef ribs, very fat, roasted.....	2	.0731	.0195	.0536	73.32	73.09	73.64
1595	Do .....	4	.0553	.0092	.0461	83.36	81.22	85.09
	Average of 2.....		.0642	.0144	.0498	78.34	.....	.....
	Average of 6.....		.0635	.0126	.0509	80.45	.....	.....
1611	Experiment No. 94: Beef ribs, very fat, raw.....	4	.0654	.0118	.0536	81.96	79.60	85.92
1615	Beef ribs, very fat, roasted.....	4	.0613	.0141	.0472	77.00	76.21	77.87
1612	Experiment No. 95: Beef ribs, very fat, raw.....	3	.0599	.0084	.0515	85.98	85.00	87.66
1614	Beef ribs, very fat, roasted.....	3	.0527	.0099	.0428	81.21	80.08	82.39
1613	Experiment No. 96: Beef ribs, very fat, raw.....	2	.0781	.0126	.0655	83.87	81.95	85.43
1616	Beef ribs, very fat, roasted.....	4	.0588	.0083	.0505	85.88	82.54	88.00
1525	Experiment No. 97: Beef ribs, very fat, roasted.....	3	.0689	.0120	.0509	82.58	81.86	82.86
1561	Do .....	3	.0809	.0174	.0635	78.49	78.40	78.72
1617	Do .....	3	.0625	.0073	.0552	88.32	88.07	88.58
	Average of 3.....		.0708	.0122	.0585	83.13	.....	.....
1634	Experiment No. 94: Beef round, cooked in water 2 hours, ground twice in a sausage mill.....	4	.1431	.0257	.1174	82.04	80.69	83.96
1635	Experiment No. 95: Beef round, cooked in water 2 hours, cut into quarter-inch cubes.....	3	.1100	.0831	.0269	24.45	23.34	26.20
<i>Digested 4 hours.</i>								
Experiments Nos. 7-11:								
Beef round—								
1202	Raw.....	4	.0923	.0053	.0870	94.26	93.96	94.40
1203	Pan broiled.....	3	.0612	.0055	.0557	91.01	90.99	91.06
1204	Fried in hot lard.....	4	.0545	.0047	.0548	92.10	91.35	92.79
1205	Cooked in water 2 hours.....	5	.0653	.0095	.0558	85.45	84.25	87.12
1206	Cooked in water 5 hours.....	4	.0763	.0101	.0662	86.76	84.80	89.39
Experiments Nos. 12-16:								
Beef round, lean—								
1210	Raw.....	4	.0916	.0056	.0860	93.89	93.25	94.36
1211	Cooked in water 2 hours.....	4	.0830	.0046	.0784	94.46	92.74	95.38
1212	Cooked in water 5 hours.....	4	.1118	.0055	.1063	95.08	94.93	95.19
1215	Pan broiled.....	4	.0689	.0047	.0642	93.18	92.50	94.05
1219	Fried in hot lard.....	4	.0907	.0102	.0805	88.75	88.21	89.25
Experiments Nos. 17-21:								
Beef round, lean—								
1235	Raw.....	3	.0922	.0089	.0833	90.35	89.50	91.43
1238	Pan broiled.....	3	.0495	.0018	.0477	96.36	96.33	96.43
1241	Fried in hot lard.....	4	.0902	.0047	.0855	94.79	94.28	95.72
1242	Cooked in water 1 hour.....	4	.0931	.0050	.0881	94.63	94.14	95.28
1243	Cooked in water 5 hours.....	3	.0936	.0058	.0875	93.80	93.56	93.97
Experiments Nos. 22-26:								
1279	Beef sirloin, very fat, broiled, underdone.....	2	.0392	.0025	.0367	93.62	93.12	94.36

TABLE 35.—*Results obtained in artificial digestion of samples of different cuts of beef, raw and cooked in different ways—Continued.*

Laboratory No.	Description of sample.	Number of tests in average.	Nitrogen in—			Proportion of total nitrogen in digested portion.		
			Meat.	Undigested portion.	Digested portion.	Average.	Minimum.	Maximum.
<i>Digested 4 hours—Continued.</i>								
1280	Beef sirloin, very fat, broiled, well done.....	4	Gram. 0.0688	Gram. 0.0063	Gram. 0.0625	Per ct. 90.84	Per ct. 89.99	Per ct. 91.74
1281	Beef sirloin, very fat, broiled, underdone.....	1	.0537	.0093	.0444	82.68	.....	.....
1282	Do.....	3	.0555	.0038	.0517	93.15	92.73	93.29
1283	Do.....	3	.0843	.0074	.0769	91.22	90.93	91.58
	Average of 5.....		.0603	.0059	.0544	90.30	.....	.....
Experiments Nos. 27-28:								
1287	Beef shoulder, very fat, cooked in water 2 hours.....	3	.0965	.0085	.0880	91.19	90.87	91.88
1300	Beef shoulder moderately fat, raw.....	3	.1146	.0106	.1040	90.75	90.35	91.21
Experiments Nos. 29-31:								
1302	Beef sirloin, very fat, raw.....	3	.0710	.0051	.0659	92.82	92.43	93.61
1303	Do.....	4	.0574	.0041	.0533	92.86	92.33	93.42
1305	Do.....	3	.0602	.0032	.0570	94.68	94.40	94.97
	Average of 3.....		.0629	.0041	.0587	93.45	.....	.....
Experiments Nos. 32-34:								
1306	Beef sirloin, very fat, broiled.....	3	.0907	.0091	.0816	89.97	89.26	91.03
1307	Do.....	4	.0809	.0068	.0741	91.59	90.96	92.32
1309	Do.....	4	.0965	.0089	.0876	90.78	90.10	91.40
	Average of 3.....		.0894	.0083	.0811	90.78	.....	.....
Experiments Nos. 35-36:								
1314	Beef round, lean, raw.....	4	.0884	.0051	.0833	94.23	94.03	94.44
1313	Beef round, lean, pan broiled, well done.....	4	.0928	.0084	.0844	90.95	90.10	91.40
Experiments Nos. 37-38:								
1331	Beef round, lean, raw.....	3	.0932	.0054	.0878	94.21	92.35	95.61
1330	Beef round, lean, fried in hot lard, well done.....	4	.1168	.0115	.1053	90.15	89.27	90.84
Experiments Nos. 39-40:								
1348	Beef round, lean, raw.....	4	.1034	.0070	.0964	93.23	92.92	93.60
1347	Beef round, lean, roasted, well done.....	3	.1066	.0062	.1004	94.19	93.69	94.56
Experiments Nos. 41-45:								
1388	Beef round, lean—Raw.....	4	.0909	.0056	.0853	93.84	93.05	94.18
1389	Pan broiled.....	4	.0863	.0044	.0819	94.90	94.27	95.73
1390	Cooked in water 2 hours, well done.....	3	.1035	.0105	.0930	89.86	89.76	90.81
1391	Fried in hot lard, well done....	3	.0913	.0079	.0834	91.35	90.82	91.63
1392	Roasted, well done.....	4	.0940	.0105	.0835	88.83	88.11	90.64
Experiments Nos. 46-50:								
1393	Beef round, lean—Raw.....	2	.0847	.0091	.0756	89.26	89.09	89.40
1394	Pan broiled.....	4	.0733	.0073	.0660	90.04	89.15	90.90
1395	Cooked in water 2 hours.....	3	.0990	.0123	.0867	87.58	86.22	89.57
1396	Fried in hot lard.....	3	.1045	.0150	.0895	85.65	84.41	86.51
1397	Roasted.....	3	.0875	.0067	.0808	92.34	90.44	93.80
Experiments Nos. 51-55:								
	Beef, different cuts, all cooked in water 2 hours—							
1399	First cut ribs, very fat .....	4	.0823	.0092	.0731	88.82	87.43	89.67
1400	Leg bone, moderately fat.....	4	.0946	.0137	.0809	85.52	84.35	87.56
1401	Second cut, neck, moderately fat.....	4	.0751	.0091	.0660	87.88	87.08	88.75
1402	Flank, very fat.....	3	.0721	.0107	.0614	85.16	82.86	87.87
1403	Round, rather fat.....	3	.0953	.0072	.0881	92.44	90.19	94.74
Experiments Nos. 67-70:								
	Beef, different cuts, all cooked in water 2 hours—							
1462	Leg bone.....	2	.0765	.0068	.0697	91.11	90.33	91.82
1463	Second cut, neck.....	4	.0481	.0069	.0412	85.65	83.29	88.57
1464	Flank, well done.....	3	.0580	.0106	.0474	81.72	80.54	82.88
1465	Round, well done.....	4	.1038	.0075	.0963	92.77	91.86	93.52

TABLE 35. Results obtained in artificial digestion of samples of different cuts of beef raw and cooked in different ways. Continued.

Laboratory No.	Description of sample.	Number of tests in average.	Nitrogen in		Proportion of total nitrogen in digested portion.				
			Meat.	Undigested portion.	Digested portion.	Average.	Minimum.		
<i>Digested 6 hours.</i>									
Experiments Nos. 7-11:									
	Beef round								
1202	Raw.....	4	.0816	.0039	.0777	95.22	94.17		
1203	Pan broiled.....	4	.0717	.0033	.0684	95.40	94.76		
1204	Fried in hot lard.....	4	.0648	.0032	.0616	95.06	94.21		
1205	Cooked in water 2 hours.....	4	.0634	.0071	.0563	88.80	87.48		
1206	Cooked in water 5 hours.....	3	.0709	.0050	.0659	92.95	92.09		
Experiments Nos. 12-16:									
	Beef, round, lean								
1210	Raw.....	4	.0843	.0041	.0802	95.14	94.65		
1211	Cooked in water 2 hours.....	3	.0939	.0031	.0908	96.70	96.08		
1212	Cooked in water 5 hours.....	4	.1010	.0065	.0945	93.56	91.22		
1215	Pan broiled.....	3	.0719	.0037	.0682	94.85	94.47		
1219	Fried in hot lard.....	3	.0869	.0084	.0785	90.33	89.46		
Experiments Nos. 17-21:									
	Beef, round, lean								
1235	Raw.....	3	.0956	.0048	.0908	94.98	94.18		
1238	Pan broiled.....	3	.0719	.0022	.0697	96.94	96.65		
1241	Fried in hot lard.....	4	.0935	.0038	.0897	95.94	95.67		
1242	Cooked in water 1 hour.....	4	.0931	.0041	.0890	95.60	95.49		
1243	Cooked in water 5 hours.....	4	.0923	.0033	.0890	96.42	96.04		
Experiments Nos. 22-26:									
	Beef sirloin, very fat, broiled, underdone.....								
1279	Beef sirloin, very fat, broiled, underdone.....	2	.0659	.0041	.0618	93.78	93.67		
1280	Beef sirloin, very fat, broiled, well done.....	3	.0708	.0046	.0662	93.50	92.78		
1281	Beef sirloin, very fat, broiled, underdone.....	3	.0418	.0040	.0378	90.43	89.76		
1282	Do.....	3	.0475	.0026	.0449	94.53	94.03		
1283	Do.....	3	.0787	.0053	.0734	93.27	93.18		
Experiments Nos. 27-28:									
	Beef shoulder, very fat, cooked in water 2 hours.....								
1287	Beef shoulder, very fat, cooked in water 2 hours.....	3	.0910	.0081	.0829	91.10	89.82		
1300	Beef shoulder, moderately fat, raw.....	4	.1153	.0074	.1079	93.59	93.53		
Experiments Nos. 29-31:									
	Beef sirloin, very fat, raw.....								
1302	Beef sirloin, very fat, raw.....	3	.0757	.0038	.0719	94.98	94.13		
1303	Do.....	4	.0662	.0039	.0623	94.11	93.13		
1305	Do.....	3	.0676	.0011	.0665	98.37	98.26		
Average of 3.....									
			.0698	.0029	.0660	95.82			
Experiments Nos. 32-34:									
	Beef sirloin, very fat, broiled.....								
1306	Beef sirloin, very fat, broiled.....	3	.0760	.0055	.0705	92.76	92.61		
1307	Do.....	4	.0772	.0051	.0721	93.39	93.14		
1309	Do.....	4	.0948	.0062	.0886	93.46	92.52		
Average of 3.....									
			.0827	.0056	.0771	93.20			
Experiments Nos. 35-36:									
	Beef round, lean, raw.....								
1314	Beef round, lean, raw.....	4	.1045	.0053	.0992	94.93	94.41		
1313	Beef round, lean, pan broiled, well done.....	3	.1127	.0081	.1046	92.81	92.44		
Experiments Nos. 37-38:									
	Beef round, lean, raw.....								
1331	Beef round, lean, raw.....	3	.0933	.0051	.0882	94.53	94.47		
1330	Beef round, lean, fried in hot lard, well done.....	3	.1001	.0085	.0916	91.51	91.20		
Experiments Nos. 39-40:									
	Beef round, lean, raw.....								
1348	Beef round, lean, raw.....	4	.0904	.0046	.0858	94.91	94.06		
1347	Beef round, lean, roasted, well done.....	4	.1015	.0054	.0961	94.68	94.22		
Experiments Nos. 41-45:									
	Beef round, lean								
1388	Raw.....	4	.0966	.0037	.0929	96.17	95.67		
1389	Pan broiled.....	3	.1067	.0047	.1020	95.60	94.96		
1390	Cooked in water 2 hours, well done.....	3	.0892	.0042	.0850	95.29	94.88		
1391	Fried in hot lard, well done.....	3	.0927	.0062	.0865	93.31	93.18		
1392	Roasted, well done.....	4	.0999	.0055	.0940	94.47	94.01		
Experiments Nos. 46-50:									
	Beef round, lean								
1393	Raw.....	4	.0951	.0078	.0873	91.80	91.61		
1394	Pan broiled.....	3	.0704	.0042	.0662	94.03	91.49		
1395	Cooked in water 2 hours.....	4	.0955	.0052	.0903	94.55	93.93		
1396	Fried in hot lard.....	3	.0945	.0110	.0835	88.36	86.17		
1397	Roasted.....	3	.1093	.0077	.1016	92.95	92.34		

TABLE 35.—Results obtained in artificial digestion of samples of different cuts of beef, raw and cooked in different ways—Continued.

Laboratory No.	Description of sample.	Number of tests in average.	Nitrogen in—			Proportion of total nitrogen in digested portion.				
			Meat.	Undigested portion.	Digested portion.	Average.	Minimum.	Maximum.		
<i>Digested 6 hours—Continued.</i>										
Experiments Nos. 51-55:										
Beef, different cuts, all cooked in water 2 hours—										
1399	First cut ribs, very fat.....	3	.0095	.0059	.0636	91.51	90.31	92.36		
1400	Leg bone, moderately fat.....	4	.0855	.0084	.0771	90.18	89.24	91.33		
1401	Second cut, neck, moderately fat.....	3	.0660	.0054	.0606	91.82	90.43	93.76		
1402	Flank, very fat.....	3	.0741	.0095	.0646	87.18	86.76	89.55		
1403	Round, rather fat.....	2	.0801	.0058	.0743	92.76	91.98	93.50		
Experiments Nos. 66-70:										
Beef, different cuts, all cooked in water 2 hours—										
1461	First cut ribs, underdone.....	3	.0547	.0057	.0490	89.58	88.28	90.69		
1462	Leg bone.....	2	.0830	.0061	.0769	92.65	92.63	92.67		
1463	Second cut neck.....	3	.0522	.0057	.0465	89.08	88.59	89.74		
1464	Flank, well done.....	4	.0535	.0076	.0459	85.79	84.38	86.90		
1465	Round, well done.....	4	.0958	.0046	.0912	95.20	94.61	95.92		
Experiment No. 94:										
1634	Beef round, cooked in water 2 hours, ground twice in a sausage mill.....	3	.1303	.0077	.1226	94.09	93.89	94.63		
Experiment No. 95:										
1635	Beef round, cooked in water 2 hours, cut into quarter-inch cubes.....	2	.1439	.0872	.0567	39.40	35.17	42.03		
<i>Digested 24 hours.</i>										
Experiments Nos. 7-11:										
Beef round—										
1202	Raw.....	4	.0833	.0025	.0808	97.00	96.53	97.74		
1203	Pan broiled.....	4	.0739	.0026	.0713	96.48	96.02	97.04		
1204	Fried in hot lard.....	4	.0679	.0025	.0654	96.32	96.03	96.54		
1205	Cooked in water 2 hours.....	4	.0680	.0031	.0649	95.44	95.09	95.64		
1206	Cooked in water 5 hours.....	3	.0722	.0026	.0696	96.40	95.93	96.63		
Experiments Nos. 12-16:										
Beef round, lean—										
1210	Raw.....	4	.0821	.0026	.0795	96.83	96.41	97.20		
1211	Cooked in water 2 hours.....	3	.0886	.0029	.0857	96.73	96.56	96.90		
1212	Cooked in water 5 hours.....	2	.1189	.0056	.1133	95.29	94.94	95.53		
1215	Pan broiled.....	3	.0836	.0038	.0798	95.45	95.34	95.41		
1219	Fried in hot lard.....	4	.0905	.0051	.0854	94.36	94.14	94.64		
Experiments Nos. 17-21:										
Beef round, lean—										
1235	Raw.....	4	.0828	.0030	.0798	96.38	95.71	96.95		
1238	Pan broiled.....	2	.0613	.0020	.0593	96.74	96.51	97.04		
1241	Fried in hot lard.....	4	.0902	.0020	.0882	97.78	97.38	98.40		
1242	Cooked in water 1 hour.....	4	.0954	.0027	.0927	97.17	97.03	97.28		
1243	Cooked in water 5 hours.....	3	.0730	.0022	.0708	96.99	96.73	97.21		
Experiments Nos. 27-28:										
1287	Beef shoulder, very fat, cooked in water 2 hours.....	4	.1006	.0034	.0972	96.62	95.99	97.37		
1300	Beef shoulder, moderately fat, raw.....	3	.0989	.0027	.0962	97.27	97.04	97.61		
Experiments Nos. 29-31:										
1302	Beef sirloin, very fat, raw.....	2	.0775	.0007	.0768	99.10	98.36	100.00		
1303	Do.....	3	.0557	.0007	.0550	98.74	97.80	99.09		
1305	Do.....	2	.0732	.0036	.0696	95.08	95.00	95.16		
Average of 3.....										
.0688										
.0017										
.0671										
97.64										
Experiments Nos. 32-34:										
1306	Beef sirloin, very fat, broiled.....	3	.0910	.0037	.0873	95.93	95.63	96.07		
1307	Do.....	2	.0701	.0025	.0676	96.51	96.43	96.59		
1309	Do.....	2	.0976	.0022	.0954	97.75	96.64	98.52		
Average of 3.....										
.0862										
.0028										
.0834										
96.73										
Experiments Nos. 35-36:										
1314	Beef round, lean, raw.....	4	.1158	.0032	.1126	97.24	96.94	97.44		
1313	Beef round, lean, pan broiled, well done.....	4	.0979	.0034	.0945	96.53	96.20	96.75		

TABLE 35.—Results obtained in artificial digestion of samples of different cuts of beef, raw and cooked in different ways—Continued.

Laboratory No.	Description of sample.	Number of tests in average.	Nitrogen in			Proportion of total nitrogen in digested portion.		
			Meat.	Undigested portion.	Digested portion.	Average.	Minimum.	Maximum.
<i>Digested 24 hours—Continued.</i>								
1331	Experiments Nos. 37-38:							
1330	Beef round, lean, raw.....	3	.0977	.0025	.0952	97.44	97.40	97.50
	Beef round, fried in hot lard, well done.....	4	.1239	.0044	.1195	96.45	96.23	96.70
1348	Experiments Nos. 39-40:							
1347	Beef round, lean, raw.....	4	.0930	.0038	.0892	95.91	95.59	96.17
	Beef round, lean, roasted, well done.....	3	.1202	.0057	.1145	95.34	94.87	95.84
1388	Experiments Nos. 41-45:							
1389	Beef round, lean—							
1390	Raw.....	4	.0851	.0019	.0832	97.77	97.66	97.92
1391	Pan broiled.....	3	.0782	.0014	.0768	98.21	97.89	98.46
1392	Cooked in water 2 hours, well done.....	3	.1048	.0044	.1004	95.50	95.05	96.80
1393	Fried in hot lard, well done....	4	.0804	.0022	.0782	97.26	96.76	97.62
1394	Roasted, well done.....	3	.0830	.0022	.0808	97.35	96.65	97.66
1395	Experiments Nos. 46-50:							
1396	Beef round, lean—							
1397	Raw.....	4	.0988	.0034	.0954	96.56	96.49	96.62
1398	Pan broiled.....	3	.0764	.0022	.0742	97.12	96.67	97.92
1399	Cooked in water 2 hours.....	4	.0748	.0023	.0725	96.93	96.83	97.20
1400	Fried in hot lard.....	4	.1028	.0037	.0991	96.40	96.00	96.89
1401	Roasted.....	4	.0941	.0024	.0917	97.45	97.26	97.55
1589	Experiment No. 92:							
1590	Beef ribs, very fat, roasted.....	2	.0761	.0059	.0702	92.25	91.54	92.85
	Do.....	3	.0580	.0028	.0552	95.11	95.06	95.16
	Average of 2.....							
			.0671	.0044	.0627	93.68		
1591	Experiment No. 93:							
1595	Beef ribs, very fat, roasted.....	3	.0711	.0047	.0664	93.39	92.78	94.31
	Do.....	3	.0581	.0033	.0548	94.32	93.78	95.14
	Average of 2.....							
			.0646	.0040	.0606	93.86		
	Average of 6.....							
			.0683	.0040	.0643	94.21		
1611	Experiment No. 94:							
1615	Beef ribs, very fat, raw.....	3	.0662	.0056	.0606	91.54	91.31	91.67
	Beef ribs, very fat, roasted.....	3	.0488	.0027	.0461	94.47	94.09	94.71
1612	Experiment No. 95:							
1614	Beef ribs, very fat, raw.....	2	.0679	.0025	.0654	96.32	95.44	97.01
	Beef ribs, very fat, roasted.....	3	.0523	.0033	.0490	93.69	92.87	94.47
1613	Experiment No. 96:							
1616	Beef ribs, very fat, raw.....	3	.0756	.0040	.0716	94.71	94.41	95.02
	Beef ribs, very fat, roasted.....	3	.0596	.0029	.0567	95.13	95.00	95.41
1525	Experiment No. 97:							
1561	Beef ribs, very fat, roasted.....	3	.0582	.0028	.0554	95.19	94.75	95.87
1617	Do.....	3	.0800	.0036	.0764	95.50	94.60	96.03
	Do.....	3	.0523	.0028	.0495	94.65	94.26	94.71
	Average of 3.....							
			.0635	.0031	.0604	95.41		
1634	Experiment No. 94:							
	Beef round, cooked in water 2 hours, ground twice in a sausage mill.....	4	.1088	.0034	.1054	96.87	96.43	97.18
1635	Experiment No. 95:							
	Beef round, cooked in water 2 hours, cut into quarter-inch cubes.....	3	.0996	.0108	.0888	89.16	86.81	91.97
1399	Experiments Nos. 51-55:							
1400	Beef, different cuts, all cooked in water 2 hours—							
1401	First cut ribs, very fat.....	2	.0796	.0032	.0764	95.98	95.12	96.73
	Leg bone, moderately fat.....	3	.0745	.0026	.0719	96.51	95.94	96.94
1402	Second cut neck, moderately fat.....	3	.0898	.0064	.0834	92.87	91.92	94.03
1403	Flank, very fat.....	2	.0590	.0042	.0548	92.88	90.96	94.71
	Round, rather fat.....	3	.0848	.0056	.0792	93.40	92.68	93.73

TABLE 35. *Results obtained in artificial digestion of samples of different cuts of beef, raw and cooked in different ways—Continued.*

Laboratory No.	Description of sample.	Number of tests in average.	Nitrogen in—			Proportion of total nitrogen in digested portion.				
			Meat.	Undigested portion.	Digested portion.	Average.	Minimum.	Maximum.		
<i>Digested 24 hours—Continued.</i>										
Experiments Nos. 66–70:										
	Beef, different cuts, all cooked in water 2 hours—									
1461	First cut ribs, underdone.....	2	.0607	.0032	.0575	94.73	94.43	94.97		
1462	Leg bone.....	4	.0841	.0029	.0812	96.55	96.51	96.78		
1463	Second cut neck.....	3	.0587	.0027	.0560	95.40	95.11	95.75		
1464	Flank, well done.....	3	.0598	.0026	.0572	95.65	95.29	96.14		
1465	Round, well done.....	4	.1006	.0032	.0974	96.82	96.10	97.12		
	Experiment No. 81:									
1520	Beef ribs, very fat, raw.....	1	.0532	.0027	.0505	94.92	.....	.....		
1537	Beef ribs, very fat, roasted.....	4	.0601	.0026	.0575	95.67	94.75	96.90		
	Experiment No. 82:									
1521	Beef ribs, very fat, raw.....	2	.0467	.0024	.0443	94.86	94.46	95.09		
1536	Beef ribs, very fat, roasted.....	3	.0572	.0036	.0536	93.71	92.75	94.85		
	Experiment No. 83:									
1522	Beef ribs, very fat, raw.....	3	.0335	.0018	.0317	94.63	93.03	96.29		
1538	Beef ribs, very fat, roasted.....	3	.0560	.0030	.0530	94.64	94.25	95.35		
	Experiment No. 84:									
1535	Beef ribs, very fat, raw.....	3	.0554	.0017	.0537	96.93	96.40	97.45		
1539	Beef ribs, very fat, roasted.....	2	.0516	.0027	.0489	94.77	94.61	94.73		
	Experiment No. 85:									
1541	Beef ribs, very fat, raw.....	3	.0524	.0024	.0500	95.42	95.09	95.80		
1540	Beef ribs, very fat, roasted.....	2	.0661	.0029	.0632	95.51	95.32	95.70		
	Experiment No. 91:									
1587	Beef ribs, very fat, roasted.....	4	.0666	.0033	.0633	95.05	94.31	95.27		
1588	Do.....	1	.0797	.0039	.0758	95.11	.....	.....		
	Average of 2.....		.0732	.0036	.0696	95.08	.....	.....		

## EXPERIMENTS WITH MUTTON.

The work with mutton consisted of a study of the relative ease of digestion of different cuts from the same animal, which was a wether about 2 years old when slaughtered. Five different cuts were used. No. 1424 was a shoulder, very fat; No. 1425 was a flank piece, very fat; No. 1426 was a leg, moderately fat; No. 1427 was a piece of loin, very fat; and No. 1428 was a rib piece, very fat. Each of these was cooked in water that was kept boiling for ten minutes, and then at 80°–85° for two hours. The experiments with these pieces of meat, Nos. 56 to 60, are given in Table 36.

TABLE 36. *Results obtained in artificial digestion of different cuts of mutton, all cooked in the same manner.*

Laboratory No.	Description of sample.	Number of tests in average.	Nitrogen—			Proportion of total nitrogen in digested portion.				
			In meat.	In undigested residue.	In digested portion.	Average.	Minimum.	Maximum.		
<i>Digested 1 hour.</i>										
Experiments Nos. 56-60: Mutton, different cuts, all cooked in water 2 hours—										
1424	Shoulder.....	1	.0760	.0135	.0625	82.24	.....	.....		
1425	Flank.....	3	.0647	.0193	.0454	70.17	68.01	71.39		
1426	Leg.....	3	.0686	.0100	.0586	85.42	84.24	87.05		
1427	Loin.....	3	.0577	.0140	.0437	75.74	74.30	76.83		
1428	Ribs.....	3	.0557	.0111	.0446	80.07	79.74	80.18		
<i>Digested 2 hours.</i>										
Experiments Nos. 56-60: Mutton, different cuts, all cooked in water 2 hours—										
1424	Shoulder.....	2	.0765	.0118	.0647	84.58	84.25	84.85		
1425	Flank.....	3	.0715	.0126	.0589	82.38	80.75	83.26		
1426	Leg.....	3	.0618	.0070	.0548	88.67	88.07	89.36		
1427	Loin.....	3	.0555	.0095	.0460	82.88	81.01	84.05		
1428	Ribs.....	3	.0552	.0091	.0461	83.51	82.64	84.27		
<i>Digested 4 hours.</i>										
Experiments Nos. 56-60: Mutton—										
1424	Shoulder.....	1	.0699	.0087	.0612	87.55	.....	.....		
1425	Flank.....	3	.0571	.0091	.0480	84.06	82.15	85.08		
1426	Leg.....	4	.0669	.0046	.0623	93.12	92.62	93.99		
1427	Loin.....	3	.0552	.0062	.0490	88.77	88.01	89.35		
1428	Ribs.....	3	.0668	.0063	.0605	90.57	87.24	92.60		
<i>Digested 6 hours.</i>										
Experiments Nos. 56-60: Mutton—										
1424	Shoulder.....	3	.0721	.0049	.0672	93.20	92.87	93.73		
1425	Flank.....	3	.0694	.0087	.0607	87.46	87.19	87.95		
1426	Leg.....	3	.0687	.0035	.0652	94.91	93.26	96.76		
1427	Loin.....	4	.0436	.0042	.0394	90.37	88.79	93.13		
1428	Ribs.....	3	.0615	.0055	.0560	91.06	89.06	93.20		
<i>Digested 24 hours.</i>										
Experiments Nos. 56-60: Mutton—										
1424	Shoulder.....	4	.0801	.0037	.0764	95.38	95.18	95.59		
1425	Flank.....	3	.0618	.0037	.0581	94.01	93.52	94.27		
1426	Leg.....	3	.0720	.0014	.0706	98.06	97.27	98.94		
1427	Loin.....	4	.0548	.0020	.0528	96.35	96.01	96.63		
1428	Ribs.....	2	.0672	.0029	.0643	95.68	94.54	96.70		

#### EXPERIMENTS WITH PORK.

The work with pork included experiments with different cuts from the same animal, all cooked in the same way, and also tests with the same cut from different animals, both raw and roasted. The samples used are here described.

Experiments Nos. 61 to 65 were made with different cuts of pork from a very fat animal about 9 months old when slaughtered. No. 1430 was a belly cut, known locally as a flitch piece; No. 1432 was fresh ham; No. 1433 was fresh shoulder, and No. 1434 was a back cut. Each piece of meat was cooked in water, which was kept boiling for ten minutes and then at 80° to 85° for two hours.

Experiment No. 71 was made with fresh ham from a corn-fed hog 8 months old. One piece (No. 1482) was not cooked and one piece (No. 1483) was roasted.

Experiment No. 72 was made with fresh ham from a corn-fed hog about 8 months old. One piece (No. 1485) was not cooked and the other piece (No. 1484) was roasted.

Experiment No. 73 was made with fresh ham from a corn-fed hog about 8 months old. One piece (No. 1487) was not cooked and the other piece (No. 1486) was roasted.

Experiment No. 74 was made with a fresh ham from an animal about 8 months old that had been fed on hominy and gluten meal. One piece (1488) was uncooked and the other piece (1489) was roasted.

Experiment No. 75 was made with fresh ham from a Duroc-Jersey hog about 8 months old that had been fed on hominy and gluten meal. One piece (1490) was not cooked and the other piece (1491) was roasted.

Experiment No. 76 was made with fresh ham from a Duroc-Jersey hog about 8 months old that had been fed on hominy and gluten meal. One piece (1492) was not cooked and the other piece (1493) was roasted.

Experiment No. 77 was made with fresh ham from a Duroc-Jersey hog about 9 months old, fed on corn and clover. One piece (1505) was not cooked and the other piece (1504) was roasted.

Experiment No. 78 was made with fresh ham from a Duroc-Jersey hog about  $8\frac{1}{2}$  months old, fed on corn and clover. One piece (1507) was uncooked and the other piece (1506) was roasted.

Experiment No. 79 was made with fresh ham from a Duroc-Jersey hog fed on corn and clover. One piece (1510) was uncooked and the other piece (1511) was roasted.

Experiment No. 80 was made with fresh ham from a Yorkshire hog. One piece (1515) was not cooked and the other piece (1514) was roasted.

Experiment No. 86 was made with fresh ham from a Duroc-Jersey hog about 8 months old, fed on peas, oats, and barley. One portion (1542) was uncooked and the other portion (1545) was roasted.

Experiment No. 87 was made with fresh ham from a Duroc-Jersey hog about 8 months old, fed on peas, oats, and barley. One portion (1543) was uncooked and the other portion (1558) was roasted.

Experiment No. 88 was made with fresh ham from a Yorkshire hog about 8 months old, fed on peas, oats, and barley. One portion (1544) was uncooked and the other portion (1559) was roasted.

Experiment No. 89 was made with two portions (1573 and 1574) of roasted ham from a Duroc-Jersey hog about 8 months old, fed on peas, oats, and barley.

Experiment No. 90 was made with two portions (1575 and 1580) of roasted ham from a Yorkshire hog about 8 months old fed on corn.

The data of the experiments are given in Table 37.

TABLE 37.—*Results obtained in artificial digestion of cuts of fresh pork, raw and cooked.*

Laboratory No.	Description of sample.	Number of tests in average.	Nitrogen in—			Proportion of total nitrogen in digested portion.				
			Meat.	Undigested portion.	Digested portion.	Average.	Minimum.	Maximum.		
<i>Digested 1 hour.</i>										
Experiments Nos. 61–65: Pork, different cuts, all cooked in water 2 hours—										
1430	Belly.....	3	0.0578	0.0144	0.0434	75.09	73.88	75.65		
1431	Middle cut.....	3	.0724	.0167	.0557	76.93	76.78	77.06		
1432	Ham.....	4	.0631	.0084	.0547	86.69	85.97	87.74		
1433	Shoulder.....	3	.0759	.0115	.0644	84.85	84.45	85.44		
1434	Pack.....	3	.0667	.0064	.0603	90.40	90.04	91.05		

TABLE 37. Results obtained in artificial digestion of cuts of fresh pork, raw and cooked—Continued.

Laboratory No.	Description of sample.	Number of tests in average.	Nitrogen in			Proportion of total nitrogen in digested portion.				
			Meat,	Undigested portion.	Digested portion.	Average,	Minimum,	Maximum.		
<i>Digested 2 hours.</i>										
<i>Experiments Nos. 61-65:</i>										
Pork, different cuts, all cooked in water 2 hours										
1430	Belly.....	3	.0624	.0102	.0522	83.65	82.90	84.67		
1431	Middle cut.....	2	.0538	.0084	.0454	84.39	83.97	84.91		
1432	Ham.....	4	.0722	.0071	.0651	90.17	89.23	91.51		
1433	Shoulder.....	3	.0674	.0072	.0602	89.32	87.85	91.11		
1434	Back.....	4	.0606	.0037	.0569	93.89	92.83	95.48		
Experiment No. 71:										
1482	Fresh ham, raw.....	3	.0422	.0043	.0379	89.81	89.05	90.26		
1483	Fresh ham, roasted.....	4	.0896	.0129	.0767	85.60	84.50	86.58		
Experiment No. 72:										
1485	Fresh ham, raw.....	4	.0488	.0057	.0431	88.32	87.08	89.71		
1484	Fresh ham, roasted.....	3	.0579	.0085	.0495	85.49	85.01	85.58		
Experiment No. 73:										
1487	Fresh ham, raw.....	3	.0599	.0047	.0552	92.15	91.84	92.29		
1486	Fresh ham, roasted.....	3	.0885	.0108	.0777	87.80	87.62	88.09		
Experiment No. 74:										
1488	Fresh ham, raw.....	2	.0690	.0058	.0632	91.59	91.30	91.72		
1489	Fresh ham, roasted.....	3	.0605	.0060	.0545	90.08	89.06	90.66		
Experiment No. 75:										
1490	Fresh ham, raw.....	3	.0686	.0044	.0642	93.59	92.03	94.89		
1491	Fresh ham, roasted.....	4	.0869	.0204	.0665	76.52	75.17	78.91		
Experiment No. 76:										
1492	Fresh ham, raw.....	4	.0707	.0113	.0594	84.02	83.05	85.24		
1493	Fresh ham, roasted.....	2	.0559	.0128	.0431	77.10	76.50	77.94		
Experiment No. 77:										
1505	Fresh ham, raw.....	3	.0628	.0094	.0534	85.03	84.41	85.94		
1504	Fresh ham, roasted.....	3	.0676	.0069	.0607	89.79	88.91	90.77		
Experiment No. 78:										
1507	Fresh ham, raw.....	4	.0661	.0073	.0588	88.96	88.59	89.61		
1506	Fresh ham, roasted.....	4	.0763	.0065	.0698	91.48	90.24	92.34		
Experiment No. 79:										
1510	Fresh ham, raw.....	3	.0677	.0085	.0592	87.44	87.24	87.79		
1511	Fresh ham, roasted.....	3	.0743	.0055	.0688	92.60	92.21	92.82		
Experiment No. 80:										
1515	Fresh ham, raw.....	3	.0753	.0110	.0643	85.39	82.05	88.18		
1514	Fresh ham, roasted.....	2	.0733	.0000	.0576	91.85	91.80	91.89		
Experiment No. 86:										
1542	Fresh ham, raw.....	3	.0643	.0083	.0500	87.09	86.46	87.40		
1545	Fresh ham, roasted.....	3	.0618	.0087	.0531	85.92	83.70	88.79		
Experiment No. 87:										
1543	Fresh ham, raw.....	3	.0669	.0092	.0577	86.25	85.09	87.64		
1558	Fresh ham, roasted.....	2	.0745	.0157	.0588	78.92	78.73	79.16		
Experiment No. 88:										
1544	Fresh ham, raw.....	3	.0792	.0074	.0718	90.66	89.94	91.61		
1559	Fresh ham, roasted.....	3	.0505	.0080	.0525	86.78	85.10	88.53		
Experiment No. 89:										
1573	Fresh ham, raw.....	3	.0781	.0080	.0701	89.76	87.01	91.04		
1574	Fresh ham, roasted.....	3	.0713	.0073	.0690	90.43	90.03	90.88		
Experiment No. 90:										
1575	Fresh ham, roasted.....	3	.0910	.0102	.0808	88.79	88.53	88.98		
1580	Do.....	2	.025	.0035	.0530	84.80	84.36	85.44		
Average of 2...										
				.0768	.0069	.0639	.86.80			
<i>Digested 4 hours.</i>										
<i>Experiments Nos. 61-65:</i>										
Pork, different cuts, all cooked in water 2 hours										
1430	Belly.....	3	.0590	.0067	.0523	88.64	88.26	88.81		
1431	Middle cut.....	3	.0549	.0059	.0490	89.25	88.11	90.07		
1432	Ham.....	4	.0618	.0035	.0583	94.34	93.88	94.82		
*1433	Shoulder.....	3	.0685	.0039	.0646	94.31	93.93	94.58		
1434	Back.....	2	.0633	.0029	.0604	95.42	95.14	95.51		

TABLE 37.—*Results obtained in artificial digestion of cuts of fresh pork, raw and cooked—Continued.*

Laboratory No.	Description of sample.	Number of tests in average.	Nitrogen in—		Proportion of total nitrogen in digested portion.				
			Meat.	Undigested portion.	Digested portion.	Average.	Minimum.		
<i>Digested 6 hours.</i>									
<b>Experiments Nos. 61–65:</b>									
	Pork, different cuts, all cooked in water 2 hours—								
1430	Belly.....	3	.0626	.0043	.0583	93.13	92.37		
1431	Middle cut.....	4	.0674	.0045	.0629	93.32	92.83		
1432	Ham.....	3	.0591	.0026	.0565	95.60	95.45		
1433	Shoulder.....	3	.0673	.0030	.0643	95.54	95.17		
1434	Back.....	2	.0653	.0029	.0624	95.56	95.26		
<i>Digested 24 hours.</i>									
<b>Experiments Nos. 61–65:</b>									
	Pork, different cuts, all cooked in water 2 hours—								
1430	Belly.....	3	.0721	.0022	.0699	96.95	95.82		
1431	Middle cut.....	3	.0644	.0022	.0622	96.58	96.42		
1432	Ham.....	4	.0721	.0021	.0700	97.09	96.78		
1433	Shoulder.....	3	.0626	.0016	.0610	97.44	97.12		
1434	Back.....	3	.0850	.0022	.0828	97.41	97.30		
<b>Experiment No. 71:</b>									
1482	Fresh ham, raw.....	4	.0566	.0022	.0544	96.11	95.67		
1483	Fresh ham, roasted.....	4	.0808	.0040	.0768	95.05	94.59		
<b>Experiment No. 72:</b>									
1485	Fresh ham, raw.....	3	.0475	.0014	.0461	97.05	96.79		
1484	Fresh ham, roasted.....	4	.0541	.0023	.0518	95.75	95.59		
<b>Experiment No. 73:</b>									
1487	Fresh ham, raw.....	3	.0669	.0026	.0643	96.11	95.72		
1486	Fresh ham, roasted.....	3	.0697	.0031	.0666	95.55	95.19		
<b>Experiment No. 74:</b>									
1488	Fresh ham, raw.....	3	.0556	.0020	.0536	96.40	96.19		
1489	Fresh ham, roasted.....	3	.0650	.0026	.0624	96.00	95.49		
<b>Experiment No. 75:</b>									
1490	Fresh ham, raw.....	4	.0733	.0024	.0729	96.81	96.64		
1491	Fresh ham, roasted.....	4	.0808	.0041	.0767	94.93	94.64		
<b>Experiment No. 76:</b>									
1492	Fresh ham, raw.....	3	.0701	.0028	.0673	96.01	95.85		
1493	Fresh ham, roasted.....	3	.0573	.0027	.0546	95.29	94.39		
<b>Experiment No. 77:</b>									
1505	Fresh ham, raw.....	3	.0709	.0028	.0681	96.05	95.82		
1504	Fresh ham, roasted.....	3	.0523	.0023	.0500	95.60	95.18		
<b>Experiment No. 78:</b>									
1507	Fresh ham, raw.....	2	.0702	.0024	.0678	96.51	96.45		
1506	Fresh ham, roasted.....	2	.0660	.0026	.0634	96.06	95.05		
<b>Experiment No. 79:</b>									
1510	Fresh ham, raw.....	3	.0657	.0021	.0636	96.80	96.53		
1511	Fresh ham, roasted.....	3	.0707	.0028	.0679	96.04	95.73		
<b>Experiment No. 80:</b>									
1515	Fresh ham, raw.....	3	.0759	.0029	.0730	96.18	96.13		
1514	Fresh ham, roasted.....	4	.0801	.0032	.0769	96.00	95.43		
<b>Experiment No. 86:</b>									
1542	Fresh ham, raw.....	3	.0831	.0050	.0781	93.98	91.69		
1545	Fresh ham, roasted.....	2	.0664	.0018	.0646	97.29	97.29		
<b>Experiment No. 87:</b>									
1543	Fresh ham, raw.....	3	.0791	.0060	.0731	92.41	91.32		
1555	Fresh ham, roasted.....	4	.0827	.0034	.0793	95.89	95.38		
<b>Experiment No. 88:</b>									
1544	Fresh ham, raw.....	4	.0773	.0028	.0745	96.38	95.16		
1559	Fresh ham, roasted.....	3	.0621	.0025	.0596	95.96	95.68		
<b>Experiment No. 89:</b>									
1573	Fresh ham, raw.....	3	.0720	.0023	.0697	96.81	96.64		
1574	Fresh ham, roasted.....	4	.0747	.0029	.0718	96.12	95.45		
<b>Experiment No. 90:</b>									
	Fresh ham, roasted.....	3	.0827	.0030	.0197	96.37	96.29		
	Do.....	3	.0524	.0030	.0494	94.27	93.53		
	Average of 2.....		.0676	.0030	.0646	95.32	.....		

### SUMMARY AND DISCUSSION OF RESULTS.

For convenience in discussion, the data of Tables 35 to 37 that are of especial significance are here summarized so as to show the different kinds and cuts of meat used, the different methods of cooking, the lengths of the digestive periods, and the average coefficients of digestibility of protein obtained.

TABLE 38.—*Summary of results of artificial digestion experiments with beef.*

Laboratory No.	Kind of meat and method of cooking.	Proportion of total protein digested when digestion was continued for				
		1 hour.	2 hours.	4 hours.	6 hours.	24 hours.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
	Beef round:					
1202	Raw.....	92	94	94	95	97
1205	Cooked in water 2 hours.....	a 51	73	85	89	95
1206	Cooked in water 5 hours.....	a 62	75	87	93	96
1203	Pan broiled.....	75	82	91	95	96
1204	Fried in hot lard.....	73	87	92	95	96
1210	Raw.....	86	91	94	95	97
1211	Cooked in water 2 hours.....	84	92	94	97	97
1212	Cooked in water 5 hours.....	88	91	95	94	95
1215	Pan broiled.....	78	87	93	95	95
1219	Fried in hot lard.....	75	82	89	90	94
1235	Raw.....	89	91	90	95	96
1242	Cooked in water 1 hour.....	84	92	95	96	97
1243	Cooked in water 5 hours.....	82	90	94	96	97
1238	Pan broiled.....	84	90	96	97	97
1241	Fried in hot lard.....	78	91	95	96	98
1388	Raw.....	89	89	94	96	98
1390	Cooked in water 2 hours.....	81	86	90	95	96
1389	Pan broiled.....	85	92	95	96	98
1391	Fried in hot lard.....	76	88	91	93	97
1392	Roasted.....	83	90	89	94	97
1393	Raw.....	83	84	89	92	97
1395	Cooked in water 2 hours.....	72	84	88	95	97
1394	Pan broiled.....	77	84	90	94	97
1396	Fried in hot lard.....	77	79	86	88	96
1397	Roasted.....	86	92	92	93	97
1314	Raw.....	88	92	94	95	97
1313	Pan broiled.....	80	88	91	93	97
1331	Raw.....	81	88	94	95	97
1330	Fried in hot lard.....	79	82	90	92	96
1348	Raw.....	84	90	93	95	96
1347	Roasted.....	88	90	94	95	95
	Average of above 8 series of experiments:					
	Raw.....	87	90	93	95	97
	Cooked in water 1 hour.....	84	92	95	96	97
	Cooked in water 2 hours.....	82	84	89	94	96
	Cooked in water 5 hours.....	85	91	92	94	96
	Pan broiled.....	80	87	93	95	97
	Fried in hot lard.....	76	85	90	92	96
	Roasted.....	85	90	92	94	97
	Beef round:					
1634	Cooked in water 2 hours, ground twice in a sausage mill.....		82		94	97
1635	Cooked in water 2 hours, cut into quarter-inch cubes.....		24		39	89
	Beef sirloin:					
1302	Raw.....	79	88	93	95	99
1303	Do.....	80	87	93	94	99
1305	Do.....	82	88	95	98	95
	Average of 3.....	80	88	93	96	98

*a* Not included in the average.

TABLE 38.—*Summary of results of artificial digestion experiments with beef—Continued.*

Laboratory No.	Kind of meat and method of cooking.	Proportion of total protein digested when digestion was continued for—				
		1 hour.	2 hours.	4 hours.	6 hours.	24 hours.
		<i>Percent.</i>	<i>Percent.</i>	<i>Percent.</i>	<i>Percent.</i>	<i>Percent.</i>
1306	Beef sirloin:					
	Broiled.....	80	87	90	93	96
1307	Do .....	80	86	92	93	96
1309	Do .....	83	86	91	93	98
	Average of 3.....	81	87	91	93	97
1279	Beef sirloin:					
1280	Broiled.....	84	86	94	94	.....
1281	Do.....	76	85	91	94	.....
1282	Do.....	74	80	83	90	.....
1283	Do.....	81	87	93	95	.....
	Average of 5.....	78	84	90	93	.....
1287	Beef shoulder:					
1300	Very fat, cooked in water 2 hours.....	79	85	91	91	97
	Moderately fat, raw.....	84	86	91	93	97
	Beef ribs, raw, average of 8 experiments.....	86	.....	.....	.....	95
	Beef ribs, roasted, average of 8 experiments.....	85	.....	.....	.....	95
	Beef ribs, roasted, average of 9 experiments.....	81	.....	.....	.....	94
1309	Beef, different cuts, all cooked in water 2 hours:					
1400	First cut, ribs .....	78	87	89	91	96
1401	Leg bone.....	67	78	85	90	96
1402	Second cut, neck .....	75	79	88	92	93
1403	Flank.....	67	73	85	87	93
	Round.....	80	89	92	93	93
	Average.....	73	81	88	91	94
1461	Beef, different cuts, all cooked in water 2 hours:					
1462	First cut, ribs .....	78	.....	.....	90	95
1463	Leg bone.....	78	85	91	93	97
1464	Second cut, neck .....	70	74	86	89	95
1465	Flank.....	68	74	82	86	96
	Round.....	83	88	93	95	97
	Average.....	76	80	88	90	96
1424	Mutton, different cuts, all cooked in water at 80° to 85° C. for 2 hours:					
1425	Shoulder.....	82	86	88	93	95
1426	Flank.....	70	82	84	87	94
1427	Leg.....	85	89	93	95	98
1428	Loin.....	76	83	89	90	96
	Ribs.....	80	84	91	91	96
	Average.....	79	84	89	91	96
1430	Pork, different cuts, all cooked in water at 80° to 85° C. for 2 hours:					
1431	Belly.....	75	84	89	93	97
1432	Middle cut.....	77	84	89	93	97
1433	Ham.....	87	90	94	96	97
1434	Shoulder.....	85	89	94	96	97
	Baek.....	90	94	95	96	97
	Average.....	83	88	92	95	97
	Ham, raw, average of 14 experiments.....	89	.....	.....	.....	96
	Ham, roasted, average of 14 experiments.....	86	.....	.....	.....	96
	Ham, roasted, average of 2 tests.....	87	.....	.....	.....	95

The figures in Table 38 show what proportions of the total nitrogen contained in the meat that was treated with the artificial digestive solution were present in the material that was dissolved when the action was allowed to continue for the lengths of time specified in the

column headings. For convenience in discussing results the data may be considered as representing the proportions of protein digested under the given conditions.

It will be observed that at the end of the 24-hour periods about 97 per cent of the protein was digested and the results were practically uniform for the different samples. At the end of the 6-hour period the proportion was about 94 per cent, and at four hours 92 per cent, and the variations in the results for the different samples in either of these periods are for the most part not especially large. The proportion of protein digested in the 2-hour period was near 90 per cent and in the 1-hour period it was generally over 80 per cent, but in these periods there were considerable variations in the results for different samples. Whatever information is to be derived from the results regarding the relative ease of digestion of the meats cooked in different ways should be supplied by the data for these later periods.

The several series of experiments with lean beef round afford excellent opportunity for comparison. One fact that is especially noticeable is the lack of uniformity in the results for different samples of meat digested under uniform conditions. For example, samples Nos. 1388 to 1392 were different portions of the same cut of beef round from one animal, and samples Nos. 1393 to 1397 were corresponding portions of a cut from another animal. With the former sample 89 per cent of the protein of the raw meat was digested in one hour and but 83 per cent of that of the roasted meat, whereas with the latter sample the coefficient for the raw meat was only 83 per cent and that for the roasted meat was 86 per cent. With the former sample the coefficient for meat cooked in water two hours was 81 per cent and with the latter only 72 per cent. Since the experimental conditions were as nearly identical as they could be made in the various series of tests, it would seem as if the fact that the two sets of samples were from different animals offers some explanation of the variations, though the coefficients for meat fried in hot lard were practically identical in both cases—76 and 77 per cent.

Averaging the results obtained in the eight series with meat from different animals tends to equalize the variations observed. The coefficients for raw meat range from 83 to 92 per cent, and the mean of these—87 per cent—is the same as the average of the eight tests. There was but one test with meat cooked one hour in water, and in this the coefficient was 84 per cent. With meat cooked two hours in water one test gave only 51 per cent of the protein digested, but this test was not entirely satisfactory and the result is not included in the average. In the other test a coefficient of 72 per cent was obtained, but in two tests the figures were 81 and 84 per cent, the average of the two being 82 per cent. In one test with meat cooked five hours in water the coefficient was 61 per cent, but this test was also not

entirely satisfactory. In the two other tests the figures were 82 and 88 per cent, averaging 85 per cent. The results of the six tests with pan broiled meat ranged from 75 to 85 per cent, averaging 80 per cent, and those for the six tests with meat fried in hot lard ranged from 73 to 79 per cent and averaged 76 per cent. It is noticeable that the meat thus cooked was in each experiment less digestible in one hour than that cooked in other ways. The average of the three tests with roasted meat is 85 per cent.

In general it may be said that the differences in the average results for raw meat and meat cooked in various ways are, on the whole, too small to be of much significance; and, especially in view of the variability in the results of individual tests, it seems fair to assume that so far as can be judged from these experiments there is no practical difference—at least not a constant one—in the ease of digestion of meat cooked in different ways. The only exception is that of fried meat; in this case, in each individual test, as well as in the average, the effect of the action of the digestive solution for one hour was less than in the case of any of the other samples, which would seem to indicate that the fried meat is perhaps not so easily digested as meat otherwise cooked.

In these eight series of tests the coefficient for raw meat was in several individual cases somewhat larger than those for the cooked meats, and it is also slightly larger in the average. This might suggest that the raw meat was more easily digested—that is, that cooking the meat will tend to decrease the ease of digestion. One fact, however, should be considered—all of the cooked meats had probably lost in cooking more or less of the water-soluble nitrogenous material that was not removed from the raw meat before digestion, and which would consequently be dissolved and form part of the digested material, and thus make the apparent digestibility of the raw meat rather larger than the actual. If allowance were made for this, the results for the raw meat, at least in the average, might perhaps be no larger than those for the cooked meat.

The experiments with samples Nos. 1634 and 1635 were planned to give some idea of the effect of more or less thorough mastication upon the ease of digestion. Each sample was from the same piece of beef round, cooked in water two hours. Sample No. 1634 was ground twice in a sausage mill to represent meat somewhat thoroughly masticated, whereas sample No. 1635 was cut into small pieces, about a quarter-inch cube, to represent meat less thoroughly masticated. Both samples were digested two, six, and twenty-four hours. The results obtained were several times larger with the ground meat than with that in cubes in both the two and six hour periods, and even with twenty-four hours' digestion the result with the more coarsely

ground meat was decidedly the smaller. The inference is that thorough chewing may have a very decided influence upon the ease of digestion of meat protein.

The results of three individual tests with raw beef sirloin agree very closely with each other in both the one and the two hour periods, and so do the results with the three corresponding tests with broiled beef sirloin; and the average of the tests with the raw beef are practically identical with the average of the results for the cooked meat in the corresponding tests. In five other tests with broiled sirloin, however, rather wide variations were found in the results for the different samples in the same period.

In eight experiments beef ribs raw and roasted were compared. In each case the meat for roasting was one portion and the meat not cooked was another portion of the same cut. With these samples digestion was carried on for only the 2 and 24 hour periods. In the results for the 24-hour period there was practical uniformity for all the samples, the variation being noticeable in the ease of only one sample. In the 2-hour period the digestibility of the raw meat ranged from 82 to 91 per cent and that of the roasted meat from 81 to 97 per cent. In one experiment the coefficient for raw meat was 91 per cent and that for roasted meat 97 per cent, whereas in another experiment the coefficient for raw meat was 90 per cent and that for roasted 82 per cent, but the average of all the tests with raw meat—86 per cent—is practically identical with that for the tests with roasted meat—85 per cent. In nine other tests with roasted meat the range is from 73 to 88 per cent and the average 81 per cent.

In one experiment five different cuts of beef from the same animal were used and in another experiment the same cuts from another animal. In four cases the results with a given cut from one animal were not much different from those for the same cut from the other animal, but in the case of the leg cut the difference was quite appreciable.

In the series of tests with different cuts of mutton from the same animal the difference between the maximum and minimum results in the one-hour period was quite wide, but in the results for digestion for two hours the coefficients agree fairly well with each other, the differences being of little practical significance. In experiments with five cuts of pork from the same animal, all cooked in the same manner, three of the cuts—ham, shoulder, and back—agree fairly well with each other in the one-hour digestion period, but the results with the other two cuts were somewhat lower than with these. In the 2-hour period the differences are slightly smaller.

There were fourteen experiments in which raw fresh ham was compared with roasted fresh ham when digestion had been carried on two and twenty-four hours. In each case the samples in the two tests were from the same piece of meat. In nine tests the coefficients in the

2-hour period were larger for the raw than for the roasted ham, and in five tests the reverse was true. The largest coefficient for the raw ham, 94 per cent, and the smallest for the roasted ham, 77 per cent, were found in the same experiment. The average for all the samples of raw ham is but little larger than that for the roasted ham.

A comparison of the relative ease of digestion of the different kinds of meat—beef, mutton, and pork—is interesting. This can be made by averaging the results of those experiments in which different cuts of the same animal were used, since in each case the method of cooking the meat was the same. In all five periods the average figures for pork are the highest, those for mutton next, and those for beef last, though the difference between the beef and the mutton is smaller in the longer than in the shorter periods of digestion. On the other hand, the average of raw fresh ham in the 2-hour period is 89 per cent, that of raw beef ribs 86 per cent, and of raw beef round 90 per cent; and that of roasted fresh ham is 86 per cent, of roasted beef ribs 85 per cent, and of roasted beef round 90 per cent.

### CONCLUSIONS.

In twenty-three natural digestion experiments with men the same kind of meat—beef round—cooked in various ways, was eaten with several other common food materials in a rather varied diet. The average digestibility of the nutrients of the total diet was as follows: Protein, 93 per cent; fat, 98 per cent, and carbohydrates, 97 per cent. These coefficients agree very closely with those found in the average of several hundred digestion experiments with varied diet.

In these experiments differences in method of cooking the meat had no appreciable effect upon the proportions of nutrients digested and absorbed from the total diet.

In forty-four experiments different kinds of meat—beef, veal, mutton, and pork—cooked in various ways, were eaten with two or three other common food materials in a very simple diet, and the digestibility of the meat alone was determined. In the average of the results of these experiments the digestibility of the protein was 98 per cent and of the fat 98 per cent.

Differences in the results obtained with different kinds of meat or with the same kind of meat cooked in different ways were too small to be of any practical significance.

The relative fatness of the meat had no appreciable effect upon the thoroughness of digestion, the nutrients of very fat meat being digested as completely as those of very lean meat, including that from which in some cases part of the visible fat had been removed before cooking.

In short, all the kinds and cuts of meat were very thoroughly digested, whatever the method of cooking.

The above-mentioned coefficients of digestibility of the nutrients of meat are those derived according to the usual method from the quantity of each in the food and the total quantity in the corresponding feces. When allowance was made for the metabolic products in the feces, the results obtained indicated that the nutrients of the meat were completely digestible.

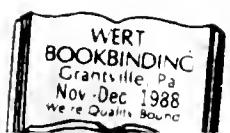
It is commonly said that meats of different sorts vary decidedly in digestibility; for instance, that red meat is less digestible than white meat or beef than pork, or that a cheap cut is less digestible than a tender steak. As regards the thoroughness of digestion the results of the extended series of tests reported show that such differences do not exist in any appreciable degree, and that meat of all kinds and cuts is to be classed with the very digestible foods.

Ninety-nine artificial digestion experiments made for the purpose of testing the relative ease of digestion of different kinds and cuts of meat cooked in different ways do not warrant any sweeping deductions. So far as can be judged from the results obtained under the experimental conditions the meat seems to be quite easily digested. About 80 per cent of the meat protein was digested in the first hour and nearly 90 per cent within two hours, whatever the kind of meat or the method of cooking, though there were considerable variations from these proportions in the individual experiments. The differences with the several kinds of meat or with meat cooked in a variety of ways are very small or very irregular, and in some cases are apparently contradictory, so it can not be said that they indicate any difference that could be attributed to the factors mentioned.

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